# Functional Allocation Issues and Tradeoffs (FAIT) Analysis of Synthetic Vision Systems (SVS)

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**Abstract**

Synthetic Vision displays provide a computer-generated view of terrain surrounding the aircraft during all phases of flight. This would allow pilots to have a clear view of the surrounding environment, similar to Visual Meteorological Conditions, regardless of weather. By increasing the pilot's situation awareness, synthetic vision systems aim to reduce Controlled Flight into Terrain (CFIT) accidents, as well as allow flight in low visibility conditions. The current research was conducted using a Functional Allocation Issues and Tradeoffs (FAIT) analysis (Riley, 1993). This method serves to identify human factors issues in human-machine systems by identifying characteristics of the system, tradeoffs between these characteristics, as well as potential sources of error within the system. Using the FAIT analysis, highly influential and sensitive characteristics were identified. These are characteristics which are critical to the functioning of the system. Also, 35 potential tradeoff situations were identified, and four scenarios were written for each. Error scenarios, which were written from an abbreviated matrix containing only highly influential and sensitive characteristics, were also developed. These scenarios document a variety of situations in which an error is likely to occur. The majority of issues relevant to the SVS considered for this analysis appear to be training issues, which suggests that many errors within the system could be mitigated with proper training. The current research gives specific recommendations of what training should be focused on. The majority of training issues were identified in the "Machine-Operator" category, which suggests that funds may be best spent on display design in order to reduce potential errors when using the SVS. This analysis should serve to identify

human factors bottlenecks within the system, and scenarios generated can be used to in future simulations to identify error, and ensure the safety of the SVS.

## Synthetic Vision Systems

In response to several high-visibility commercial transport accidents, the white house established a Commission on Aviation Safety and Security in August 1996. The following year, President Clinton announced a national goal to reduce the aviation fatal accident rate by 80% in ten years. In response to this goal, NASA created the Aviation Safety Program. An element of this program is the Synthetic Vision Systems (SVS) project, which is designed to increase safety in low visibility conditions.

The SVS would provide a computer-generated view of the terrain surrounding the aircraft, which is based on static geographical data provided by digital elevation maps (DEM's) or digital terrain elevation data (DTED), and a global positioning system (Williams, Waller, Burdette, Doyle, Capron, Barry & Gifford, 2000). This technology has also been made possible by NASA'a Shuttle Radar Topography Mission (SRTM), which successfully mapped 80% of the earth's land surfaces for SVS en route requirements (99.96% of land between 60° N. and 56° S. latitude). This artificial view of the terrain would allow pilots to have a clear view of the external environment regardless of current weather conditions, which would allow flight in near zero visibility conditions. SVS would be useful in all phases of flight, including departure, en route, approach, landing, and taxi (Williams et al. 2000). Although SVS may make flight in zero/zero conditions (Category IIIc) possible, the current focus at this time is to make flight possible in "low visibility" (Category IIIb or better) conditions (Williams, 2000). This would reduce the required Runway Visual Range (RVR) to 300 feet.

**<u>Objectives of the SVS Project</u>**

For the remainder of this paper, Synthetic Vision Systems will be discussed as they apply to commercial and business aircraft, considering that currently this is the market that synthetic vision systems are designed for. The general objective of SVS is "…to develop cockpit display systems with intuitive visual cues that replicate the safety and operational benefits of flight operations in clear-day Visual Meteorological Conditions" (Williams, et al. 2000). In other words, the SVS would allow adherence to Visual Flight Rules (VFR) in Instrument Meteorological Conditions (IMC).

Other specific objectives of SVS include developing affordable, certifiable, display configurations, which provide pilots with an intuitive view of the external environment as well as intuitive obstacle detection (Williams, 2000). SVS is also designed to reduce Controlled Flight into Terrain (CFIT) accidents, a leading cause of fatality in aviation each year. CFIT is was the cause of 36.8% of accidents, and 53.6% of fatalities from 1988 to 1993 in the commercial sector.  CFIT accidents were also to blame for 30% of General Aviation accidents in the United States. These accidents frequently occur in the approach phase of flight, and could be mitigated if the pilot had a clear view of terrain surrounding the destination airport. In addition to CFIT accidents, SVS should also reduce accidents in the landing phase of flight, runway incursion accidents, mid-air accidents, and rejected take-off accidents.

SVS are also proposed to aid in aircraft navigation by providing guidance cues and highlighting terrain and obstacle information (Williams). Using GPS and databases that provide information about the surrounding terrain, pertinent obstacles, and target airports, SVS would aid in the approach and landing phase of flight, as well as airport surface navigation. Because some major airport taxi-ways are extremely complicated, SVS would allow the pilot flying (PF) to highlight the correct path, as well as other ground traffic, and target structures such as gates and deicing facilities.

**Description of SVS**

It is important to note that the SVS used for the current analysis did not include all proposed features of SVS listed above. Because synthetic vision systems are not currently in common use, there is no single defined system on which to conduct an analysis. Therefore, this section will provide a general description of all technology proposed for SVS, and will then give an explanation of the SVS used for the current analysis.

The main element of the SVS is the virtual visual environment, which mimics what could be seen out-the-window in optimal visibility conditions. Although Head-Up Display (HUD) versions have been suggested, the SVS is currently depicted on a Head-Down Display (HDD) (Comstock, Glaab, Prinzel & Elliot, 2001). This display will most likely be 757 EADI (5 x 5.25 in.), 777 PFD (6.4 x 6.4 in.) or a rectangular flat-panel (8 x 10 in.). This display would use either a photo-realistic format, a less detailed terrain texture, or a wire-frame rendering in which a “fish-net” appears to overlay surrounding terrain (Williams, 2000). While viewing surrounding terrain, pilots will most likely have access to four Field of Views (FOV), which would be pilot selectable. The SVS display is also proposed to highlight salient features of the external environment, which are critical to safe operation of the aircraft, even in optimal visibility conditions. In addition to these highlighted features, the SVS would also have the capability to accurately depict the location of the aircraft in relationship to other features on the display (Williams, 2000). Ground traffic, surface vehicles, obstacles such as buildings and towers, target structures such as gates or deicing facilities, may also be displayed via the SVS (Williams, 2000). However, varying structures, such as ground traffic and surface vehicles, or newly built structures, which would not be in the terrain database, would be detected through an externally mounted sensor. Although weather and turbulence information will probably not be incorporated into the display in the near future, wake turbulence protection may be provided through detection using NASA's Aircraft Vortex Spacing System (AVOSS) (Williams, 2000).

Primary Flight Display (PFD) information would be overlaid on the SVS display and would include vertical speed, velocity vector, and location of ownship with respect to navigation fixes (Williams, 2000). Flight path navigation would be enabled by the GPS. Waypoints would most likely be overlaid on the SVS, and a highway in the Sky (HIS) could be used in the form of "boxes" which the pilot flies through, or "stripes" which the pilot flies over, in order to guide the pilot along the flight path. A follow-me-airplane may also be used for additional guidance information. Enhanced flight information such as taxi-maps, and taxi-path aids may also be include on the SVS display. It is also possible that the SVS would have Airborne Information for Lateral Spacing (AILS) display capability or self-spacing algorithms, assuming that traffic information is displayed. In the future, SVS may be able to provide pro-active decision making information to support self-separation, curved IMC approaches, and noise abatement procedures.

The externally mounted sensor is proposed to either use conventional radar, Forward Looking Infrared Radar (FLIR), or possibly MiliMeter Wave Radar (MMWR) (Williams, 2000). The sensor could also be an imaging sensor, such as a video camera. It is possible that this sensor would detect ground and air traffic in close proximity, construction areas, newly built structures, and wildlife. Information from the sensor and from terrain databases would be automatically blended to produce one image. In this way, the sensor could be used for database integrity monitoring.

## Description of the SVS Used for the Current Analysis

As mentioned above, SVS is not currently in common use in commercial, transport, or general aviation aircraft, and there is therefore no single defined system. Instead, as is evident in the above description of SVS, many elements to be incorporated into the system have been proposed. In light of this fact, and because of limited availability of information regarding current SVS, this analysis used a somewhat simplified version of a SVS.

The current research focused on a basic synthetic vision display in which an artificial view of the terrain is overlaid on a PFD (see Appendix A). For our uses, this virtual visual environment was assumed to mimic what could be seen out the window in clear weather conditions. We assumed that this display would use one of three pictorial scene information densities. These densities were photo-realistic, less detailed texture, or wire-frame rendering. It was also assumed that the display was head-down, and was one of the three possible sizes mentioned in the previous section (757 EADI, 777 PFD, or Rectangular Flat Panel). The SVS used for this analysis was assumed to have four possible FOV that were pilot selectable. The pilot would also have the option of decluttering the display by using some type of "declutter button" such as that defined by Norman and Hughes (2001). There would also be and auditory or visual alert which warned the pilot of immanent collision with terrain. PFD data would be overlaid on the SVS display, and this would not be selectable. PFD data would include altitude, airspeed, ground speed, attitude, vertical speed, velocity vector, and location with respect to navigation fixes. Obstacles in proximity of ownship, runway edges, and other salient features would be depicted via terrain databases. For the purposes of this analysis an externally mounted sensor was not considered. Therefore, objects such as newly built structures, ground vehicles and other traffic, wildlife; etc. would not be depicted. Also, guidance information such as a highway-in-the-sky, and a follow-me-airplane, were also not considered. When looking at the following analysis it is important to keep in mind this simplified version of the SVS. This analysis identifies basic human factors issues and bottlenecks, and is not intended to be an exhaustive analysis of all possible elements of SVS.

Note that all characteristics associated with the SVS used in this analysis are stable except for display size, pictorial scene information density, and type of alert. These particular characteristics can be of several types, and all will be considered.

## **Goal of the Current Analysis**

The current research was conducted using a Functional Allocation Issues and Tradeoffs (FAIT) analysis (Riley, 1993). This analysis can be thought of as a task analysis, but one that produces more output than traditional task analyses (Comerford & Uhlarik, 2000). Using this method as an early front-end analysis allows one to systematically identify human factors issues in human-machine systems. In this way, the analysis allows the user to identify important characteristics of the system in question, tradeoffs between these characteristics, as well as potential sources of error within the system.

**Overview of the FAIT Analysis**

The FAIT analysis is designed to answer six basic questions (Riley, 1993): 1.) what human factors issues are relevant to the system under consideration? 2.) what types of requirements need to be written to address human factors issues? 3.) what are all the possible sources of and consequences of error in the system? 4.) what types of information should the operator have available to prevent, detect, or recover from errors? 5.) what are the most important characteristics of the system from a human factors perspective? 6.) what tradeoffs need to be made in the development of the system? In order to answer these questions, the user carries out three basic tasks. First, a general human-machine model is used along with taxonomy of autonomy and intelligence in order to create a model of information flow for the system under consideration. This information flow model consists of relevant sections of the general model provided by Riley (1993) (see Figure 1). Next, the information flow model is used to create a list of characteristics for the system. Characteristics are developed for each node in the model and are relevant to the environment in which the system functions, the machine itself, and the human operator. Last, pairwise comparisons are made between characteristics to determine how the characteristics interact during real-time operations of the system.

The FAIT analysis is useful for analysis of a synthetic vision system because it can be used on systems that have not been implemented, such as SVS. While typical analyses narrow the problem down, the FAIT analysis opens the problem up by identifying concrete physical characteristics of the machine, as well as more abstract characteristics, and psychological constructs relevant to the human-machine interface such as situation awareness and mental workload. The FAIT analysis also yields numerical values that represent the relative influence and sensitivity of these characteristics. In this way, the FAIT analysis provides a variety of useful information. Also, previous applications of the FAIT analysis to AILS and CDTI (Cockpit Display of Traffic Information) have identified many human factors issues as well as error and tradeoff scenarios that can be used for a variety of applications (Uhlarik & Comerford, 1999, Comerford & Uhlarik, 2000).

**Preliminary Step**

In the preliminary step, the user defines relevant components of the SVS system, the human user and the environment in which the system will be implemented (see Appendix A). The environment considered for this analysis was the approach and landing phases of flight. Although the SVS is capable of supporting all phases of flight, we will be focusing only on approach and landing because these are the most complex phases of flight and therefore have the potential for many human factors issues to arise. With respect to the human component of the SVS system, only the pilot flying (PF) was considered. However, pilots of other aircraft, as well as other crew member will occasionally be considered to the extent with they affect the PF. The particular SVS system used in this analysis is defined in the above section titled "Description of the SVS Used for the Current Analysis".

**Step One: A Model of Information Flow**

In order to develop a model of information flow within the SVS, one starts with the general model of information flow, and then systematically reduces this model in order to fit the system under consideration. In order to accomplish this, automation is broken down into autonomy and intelligence of the system (see Table 1). The user first defines the autonomy and intelligence level of the system by asking a series of questions (see Appendix A). The FAIT users manual provides a complete list of questions, as well as various templates representing all possible combinations of the twelve levels of automation and seven levels of intelligence that can be used in order to complete this step (Riley, 1993). The general model represents the highest level of automation (see Figure 1).

| LEVELS OF AUTONOMY \ LEVELS OF INTELLIGENCE | raw data | procedural | context responsive | personalized | inferred intent responsive | operator state responsive | operator predictive |
|---|---|---|---|---|---|---|---|
| none | | | | | | | |
| information fuser | | | | | | | |
| simple aid | | | | | | | |
| advisor | | | | | | | |
| interactive advisor | | | | | | | |
| adaptive advisor | | | | | | | |
| servant | | | | | | | |
| assistant | | | | | | | |
| associate | | | | | | | |
| partner | | | | | | | |
| supervisor | | | | | | | |
| autonomous | | | | | | | |

Table 1. Levels of intelligence and autonomy provided by Riley (1993).

Autonomy is defined as “How much authority the automation has to manipulate information and perform actions” (Riley, 1993, p.3). When defining the level of intelligence, one considers what type of information the automation is capable of using.

First, it was determined that the level of autonomy for the SVS system was "Information Fuser". This level of autonomy refers to a system that is capable of collecting information and putting it in the best format for presentation to the operator (Riley, 1993). The SVS used for this analysis is basically and terrain-rendering display overlaid with PFD data. This display would be capable of taking information from terrain databases and presenting this to the operator via the SVS display, and therefore the system would fit into this category.

Second, the level of intelligence for the SVS was defined as "Personalized". This level of intelligence assumes that the machine uses imbedded models of the operator, and would refer to a system that can be personalized to present information in the particular way that the operator wants it (Riley, 1993). Even in our simplified version of the SVS, the operator can select the FOV, and also has the option to declutter the display. In this way, the system is somewhat personalized to the individual user.

The levels of "Information Fuser" and "Personalized" resulted a reduced version of the information flow chart (see Figure 2). This chart was then decomposed into characteristics of the system.

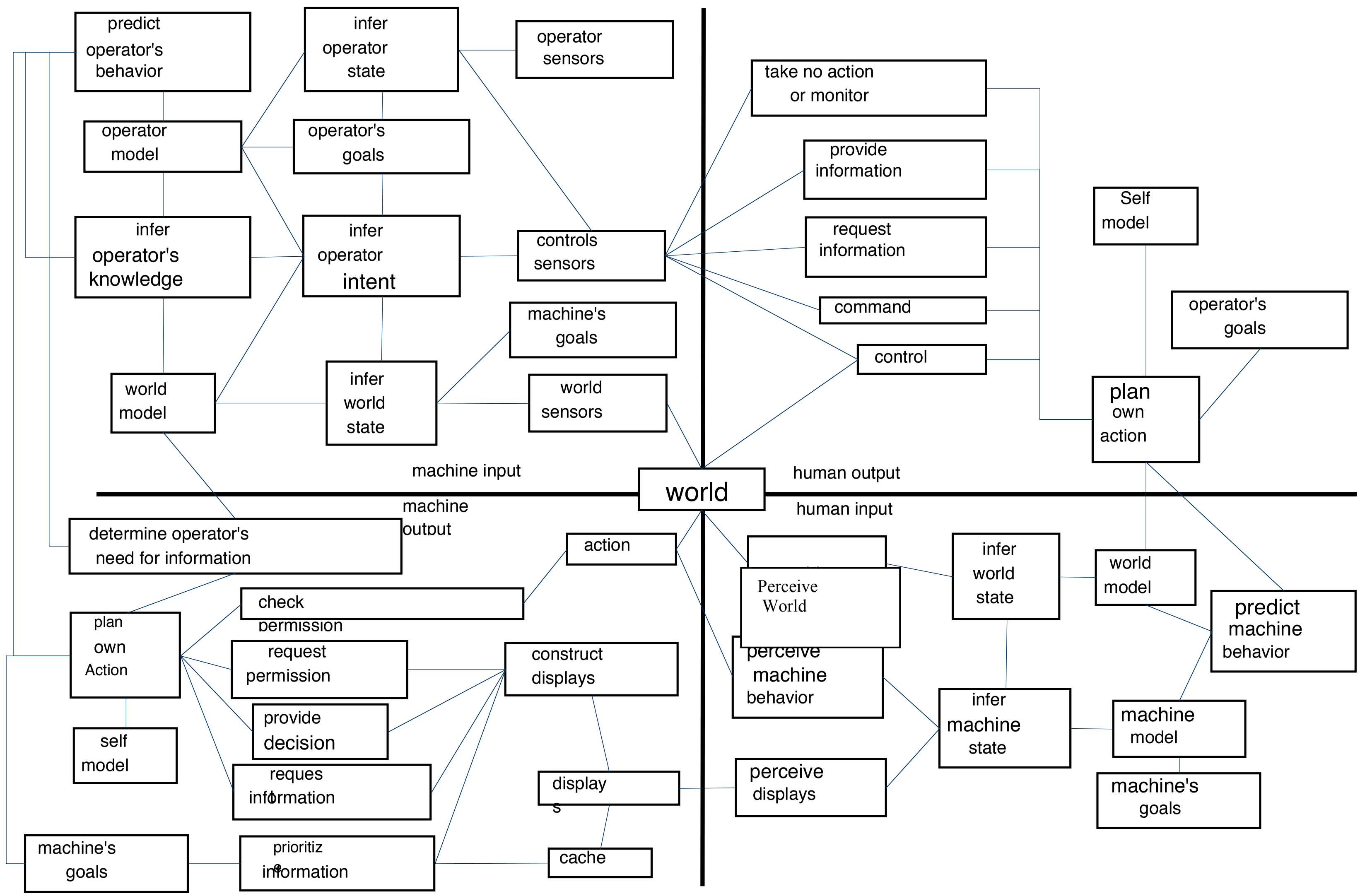


**Figure 1.** The general model of information flow (Riley, 1993).

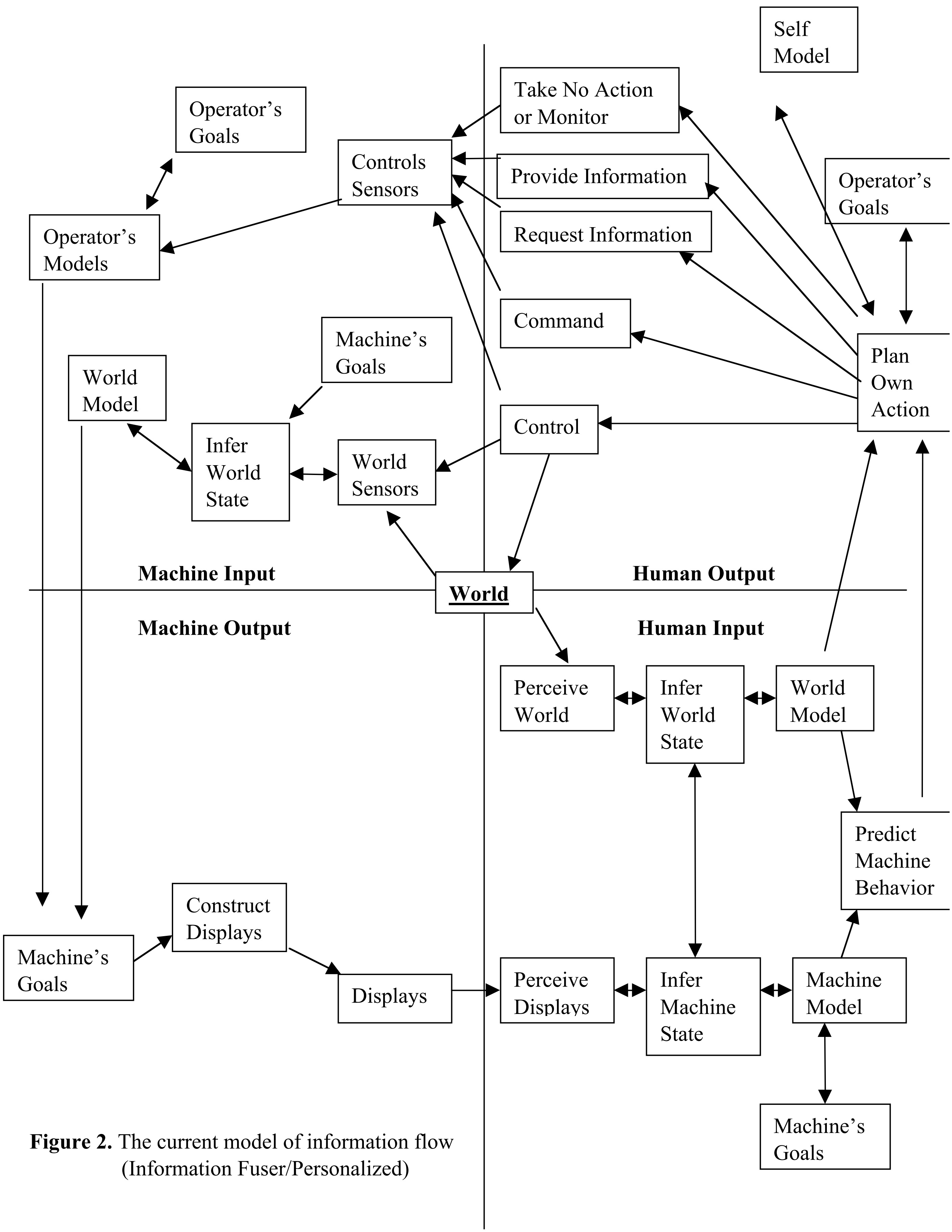


**Figure 2.** The current model of information flow (Information Fuser/Personalized)

**Step two: Identify Characteristics**

In this step characteristics are identified for each node or "box" within the information flow model (see Appendix B). In this step all characteristics of the operational environment and all related systems that have the potential to influence or be influenced by the system are considered (Riley, 1993). The user's manual provides descriptions of each node, and example characteristics for each. In order to make this process more systematic, Uhlarik and Comerford's (1999, 2000) method was used. In this method a question is created for each node, and resulting characteristics are noted. A characteristic is defined as "An aspect of the system that can vary from a desirable to an undesirable state" (Uhlarik & Comerford, 2000, p. 15). Characteristics in a desirable state lead to proper functioning of the system, while an undesirable state would lead to some malfunction or error. It is important to note however, that several characteristics such as "Display Size" and "Auditory vs. Visual Warning" and "Pictorial Scene Information Density" do not fit this typical definition. Although it is likely that these characteristics do indeed have desirable and undesirable states, research has not yet concretely demonstrated this, and it is beyond the scope of this analysis to do so. Therefore, all possible variations listed in the description of the system were considered.

For example, the "World Model" node represents the operator's level of understanding about the operational environment. The questions asked for this node was "What affects the pilots current mental model of (or awareness of) the SVS environment?" Examples of resulting characteristics are "Current level of SA", "Amount of time spent looking out-the-window", "Accuracy of pilots mental model of the environment" and "Degree of pilot fatigue". These characteristics are related to the "Operator" component of the system. Other nodes relate to the machine and environment components of the system. An example of a “Machine” node is the “Perceive Displays Node”, which refers to the operator’s act of reading the displays. The question asked for this node was “What affects the pilots ability to perceive information from the SVS display?” Examples of characteristics resulting from this node are “Glare on the SVS”, “Color of Terrain”, “Degree of overlay with PFD data”, “Number of layers in the menu structure”, and “Size of symbols/text” (see Appendix B for a complete list of characteristics).

Because related systems, as well as characteristics of the operational environment are considered, the list of characteristics is quite extensive, resulting in 77 characteristics of the system (see Appendix A). Each characteristic is only counted once, even if it is listed under more than one node.

**Step Three: A Matrix of Characteristics**

For this step, characteristics identified in step two were divided into three components of the system, “Environment”, “Operator”, and “Machine”. The information flow chart is divided into four quadrants “Human Input”, “Human Output”, “Machine Input”, and “Machine Output”. The characteristics are therefore naturally divided into the four components of the environment in this way. However, characteristics sometimes appear in both human and machine quadrants. When this happens, characteristics are placed in the category to which they most intuitively belong (see Appendix B). For example, “Level of pilot fatigue” obviously belongs in the “Human” quadrant although it may affect some aspect of the machine.

Once the characteristics were divided, they were then placed in a matrix, which lists each characteristic twice, once along the left margin of matrix, and once along the top (see Appendix C). These two axes are therefore identical. On one axis, the characteristics are referred to as "Drivers" and on the other, they are referred to as "Receivers" (see Table 2). "This means that the left side characteristic will drive the relationship in the questions considered, and the top characteristic will receive any requirements generated by the relationship" (Riley, 1993, p. 40).

| | | **Receivers** | | |
|---|---|---|---|---|
| | | Characteristic 1 | Characteristic 2 | Characteristic 3 |
| | Characteristic 1 | | 1 | |
| **Drivers** | Characteristic 2 | 1 | | 1 |
| | Characteristic 3 | | | |

**Table 2.** Matrix structure.

Dividing the Drivers and Receivers into "Environment", "Operator" and "Machine" components, results in nine regions based on the relationship between these components. Entries in these sections then give information as to what regions are important in the design of the system. The implications of entries in these regions will be discussed in detail in a later section.

By listing each characteristic twice, the relationship between every possible pair of characteristics is considered. To complete this step, two questions were asked for each cell: 1.) Does the driver influence the receiver during real time operations of the system? 2.) Does the driver place a requirement on the receiver? These questions were asked for each of the close to 6000 cells in the matrix. If the answer was yes to either question, then an entry of "1" was placed in the matrix (see Appendix A). The gray area along the negative diagonal in the matrix represents cells in which identical characteristics interact, and their relationship is therefore not considered.

An example of an "influence" entry would be the interaction between the characteristics "Glare on the SVS" and "Level of mental workload". If the SVS display is not readable, then the pilot will be forced to gain pertinent information from another source. An example of an "requirement" entry would be the interaction between the characteristics "Level of noise in the cockpit" and "Auditory vs. visual warning". When the volume of noise (driver) in the cockpit is high, a visual warning (receiver), as opposed to an auditory warning, may be required.

**Step Four: Estimates of the Relative Importance of Characteristics**

By summing the rows of the matrix, influence totals are derived and by summing the columns, sensitivity totals for each characteristic are derived. Influential characteristics are those that drove the largest number of interactions, and the most sensitive characteristics are those that received the largest number of interactions. The most influential and sensitive characteristics represent characteristics that are essential to the functioning of the SVS system. These characteristics can be used to determine what the priorities should be for devoting design resources, and where the largest potential problems are likely to lie (Riley, 1993). Riley (1993) also states that characteristics, which are both highly sensitive and highly influential, are potential sources of instability within the system and should therefore be considered in the implementation of the SVS. All characteristics are listed in Appendix D in order of their relative influence and sensitivity rankings within each component of the system, as well as overall. Riley (1993) sets no definite criteria for identifying the most important characteristics, and not all relationships can be considered because of the large number of cells. Therefore, Uhlarik and Comerford's (1999) method was utilized.

In this method, only influence and sensitivity scores falling above a certain percentile are considered. The $90^{th}$ percentile and above was considered in previous analyses, however, the current research considered characteristics falling above the $80^{th}$ percentile (step 1). In addition to this method, the current analysis also divided the influence and sensitivity rankings into the three components of the SVS (Environment, Human, and Machine) and considered characteristics that fell above the $80^{th}$ percentile in each component (step 2). This was done because following completion of step one, it was obvious that most characteristics falling above the $80^{th}$ percentile were part of the “Human” component of the system. It was therefore possible that important characteristics of other components (Environment and Machine) were being ignored (See Appendix E).

The most Influential Characteristics Overall were as follows:

- Intuitiveness/usability of the SVS
- Difficulty of terrain environment surrounding destination airport
- Experience and ability of the pilot
- Difficulty of the approach
- Accuracy of GPS
- Accuracy of the terrain database
- Difficulty of landing
- Functioning/malfunctioning of displays other than the SVS
- Pilot Preference
- Limitations of the machines processor
- Pictorial Scene information density

The most Sensitive Characteristics Overall were as follows:

- Level of mental workload
- Difficulty of landing
- Difficulty of approach
- Amount of time spent reading instruments other than the SVS
- Amount of time spent viewing the SVS display (head-down time)
- Current level of SA
- Accuracy of the pilots mental model of the environment
- Amount of time spent looking out-the-window

The most Influential (I)/Sensitive (S) Characteristics in the “Operator” Category are as follows:

- Experience and ability of the pilot (I)
- Pilot preference (I)
- Experience using the SVS (training) (I)
- Amount of display cross-checking (I)
- Amount of time spent looking out-the-window (I/S)
- Amount of time spent viewing the SVS display (I/S)
- Level of pilot mental workload (I/S)
- Amount of time spent reading instruments other than the SVS (S)
- Current level of SA (S)
- Accuracy of pilots mental model of the environment (S)

The most Influential (I)/Sensitive (S) characteristics in the “Environment” Category are as follows:

- Difficulty of terrain environment at destination airport (I)
- Difficulty of landing (I/S)
- Difficulty of approach (I/S)
- Functioning/malfunctioning of displays other than the SVS (I)
- ATC workload (S)
- Altitude of the aircraft (S)
- Speed of the aircraft (S)

Most Influential (I)/Sensitive (S) Characteristics in the “Machine” Category are as follows:

- Intuitiveness/usability of the SVS (I/S)
- Accuracy of the GPS (I)
- Accuracy of the terrain database (I)
- Limitations of the machines processor (I)
- Pictorial scene information density (I)
- Glare on the SVS (I)

- Degree of display clutter (S)
- Degree of overlay with PFD data (S)
- Auditory vs. visual warning (S)
- Display size (S)
- Color of symbols/text (S)
- Color of terrain (S)
- FOV currently depicted on the SVS display (S)

When the characteristics were not separated by category, only the characteristic "Difficulty of approach/landing" was ranked as both highly influential and highly sensitive. This characteristic refers to the difficulty of the terrain environment surrounding the airport, and the resulting difficulty of the landing itself. The SVS is designed to aid pilots in navigating through difficult terrain environments, so the SVS should server to mitigate any possible errors caused by terrain difficulty.

When the characteristics were separated by category, four characteristics were rated as both highly sensitive and highly influential. These characteristics were "level of mental workload", "Amount of time spent viewing the SVS (Head-down time)", "Amount of time spent looking out-the-window (Head-up time) ", and "Intuitiveness/usability of the SVS". This suggests that these characteristics are critical to the functioning of the system. For example, these characteristics suggests that if nothing is done to correct the error, the following states are likely to occur: high-level of mental workload, excessive head-up time, and insufficient amount to time spent viewing the SVS. In order to avoid these states, the PF should have a substantial amount of experience with the SVS, so that he/she has a high level of trust in the system and is comfortable spending the majority of time viewing the SVS display, since the SVS should be primarily used to navigate through terrain in less than optimal weather conditions.

It should also be noted that the most influential and sensitive characteristics are somewhat general, and that may be the reason they rate high in importance. Therefore, it is important to look at all of the characteristics listed above, as they have potential to seriously affect the SVS system and environment.

Future applications of the FAIT analysis to a synthetic vision system may wish to use subject matter experts in order to get a better idea about which characteristics are essential to the functioning of the system, in a manner similar to that used in Comerford and Uhlarik (2000).

**Step Five: Tradeoffs**

In this step, tradeoff relationships between characteristics are identified. To accomplish this, the matrix is folded along the negative diagonal, and symmetrical relationships that have the potential for a tradeoff relationship are identified (see Table 3). A potential tradeoff represents a situation in which the characteristics being considered both effect each other during real time operations of the system. In other words, “characteristic 1” influences “characteristic 2”, and “characteristic 2” influences “characteristic 1”. This resulted in 188 symmetrical relationships. However, because cells on both sides of the negative diagonal are highlighted, symmetrical relationships between two cells only count as a single tradeoff relationship. Therefore, 94 potential tradeoff relationships were identified. Because of the large number of potential tradeoff relationships, abbreviated matrices using only the most influential and sensitive characteristics listed in step four were used in this step. This resulted in a total of 35 potential tradeoff scenarios; each of these scenarios illustrates a set of circumstances in which a potential tradeoff could occur (see Appendix F).

| | | Receivers | | |
|---|---|---|---|---|
| | | Characteristic 1 | Characteristic 2 | Characteristic 3 |
| Drivers | Characteristic 1 | | 1 | |
| | Characteristic 2 | 1 | | 1 |
| | Characteristic 3 | | | |

**Table 3.** Tradeoff relationships are highlighted in yellow.

Each pair of characteristics examined in this step has to be considered as a driver and as a receiver. Also, the definition of a characteristics, that is something that varies from a desirable to an undesirable state, introduces another complication. This definition suggests that each characteristic must be looked at in terms of its desirability in the system increasing and decreasing ("Glare on the SVS display could range from "No Glare" (desirable), to "Unreadable display" (undesirable)). Because each characteristic is also considered as a driver and as a receiver, this results in four potential tradeoff scenarios for each pair of characteristics. Although Riley (1993) does not specifically suggest this method, it is a more systematic way of identifying possible tradeoff situations (Comerford & Uhlarik, 2000).

In order for a pair of characteristics to represent a true tradeoff relationship, the characteristics must be inversely related in terms of desirability. An increase in the desirability of "characteristic 1" must lead to a decrease in the desirability of "characteristic 2" and vise versa. It is possible that one or two of the four scenarios generated for each pair may represent a tradeoff, while other scenarios for that pair represent direct relationships (an increase in the desirability of "characteristic 1 leads to an increase in the desirability of "characteristic 2"). In this case, the pair of characteristics is labeled "unstable" (see Appendix F).

It is also possible that a potential tradeoff scenario cannot be imagined for pairs of characteristics, in this case, a true tradeoff situation most likely does not exist, and the pair is discarded. Pairs of characteristics for which a scenario could not be imagined are noted in Appendix F.

As mentioned above, characteristics that did not, for our purposes, range from a desirable to an undesirable state were also identified. Because these characteristics do not fit the definition, only one potential tradeoff scenario is written for each pair. These pairs are labeled "Non-Varying Characteristics" and can be found in Appendix G.

Of the 24 pairs of characteristics that did vary from an undesirable to an desirable state, 17 were found to represent "unstable" relationships, 6 were labeled as "Direct" relationships, and one was found to be a true "tradeoff" scenario (see Appendix F).

However, the type of relationship identified is not as important as the scenarios that are generated for each pair of characteristics. The criteria for determining a true tradeoff relationship is somewhat stringent, and this is most likely the reason that only one true tradeoff relationship was identified. Also, it is important to notice that even those pairs of characteristics classified as unstable often have tradeoff scenarios within them, but are not classified as true tradeoffs because all four scenarios do not represent tradeoffs. For the Non-Varying Characteristics, all 11 scenarios identify tradeoff scenarios, and all can be found in Appendix B.

Riley (1993) suggests that the identification of potential scenarios is one of the most useful products of the FAIT analysis. Each of the potential tradeoff scenarios represent important issues relevant to a synthetic visions system. Also, many useful human factors issues that could arise in the system were identified. It is suggested that these scenarios are used as a starting point to identify basic issues and to explore more detailed scenarios that are relevant to SVS.

**Step Six: Error Scenarios**

In this step potential errors that could adversely effect the functioning of the SVS are identified (see Appendix H). In order to accomplish this an abbreviated matrix is created. This matrix contains only highly influential and sensitive characteristics identified in step four. It is important to note that this abbreviated matrix is different from that used to identify tradeoff scenarios. The matrix used in this step does not contain identical axes. The left hand portion of the matrix contains highly influential characteristics, while the upper portion of the matrix contains only highly sensitive characteristics. Therefore, there is not negative diagonal in which the characteristics interact with themselves. This is because the characteristics interact in a one-way fashion.

Also, in this step, several characteristics were eliminated. For example, the characteristic “Difficulty of approach” was found to be both highly influential and highly sensitive. However, this is most likely the case because it is a very general characteristic and will therefore effect and be affected by many characteristics in the system. Error scenarios are meant to be more specific than tradeoff scenarios created in step five, therefore more general characteristics were not used in order to produce more specific scenarios.

All error scenarios found in Appendix H identify other possible human factors issues that could arise in the SVS environment. In addition to identifying human factors issues, these scenarios can be used for future simulations of SVS in order to attempt to mitigate any errors that could arise in the system.

## Step Seven: Overall Trends

Riley (1993) provides pre-specified classifications in order to examine overall trends in the system. Because the matrix is divided into the three components of the system (environment, machine, and operator) on both axes, this allows for the matrix to be divided into nine regions based on the relationships between these three components. Entries in each region represent “Training Issues”, “Automation Issues”, or “Operator-Driven System Design Issues” (see Table 5).

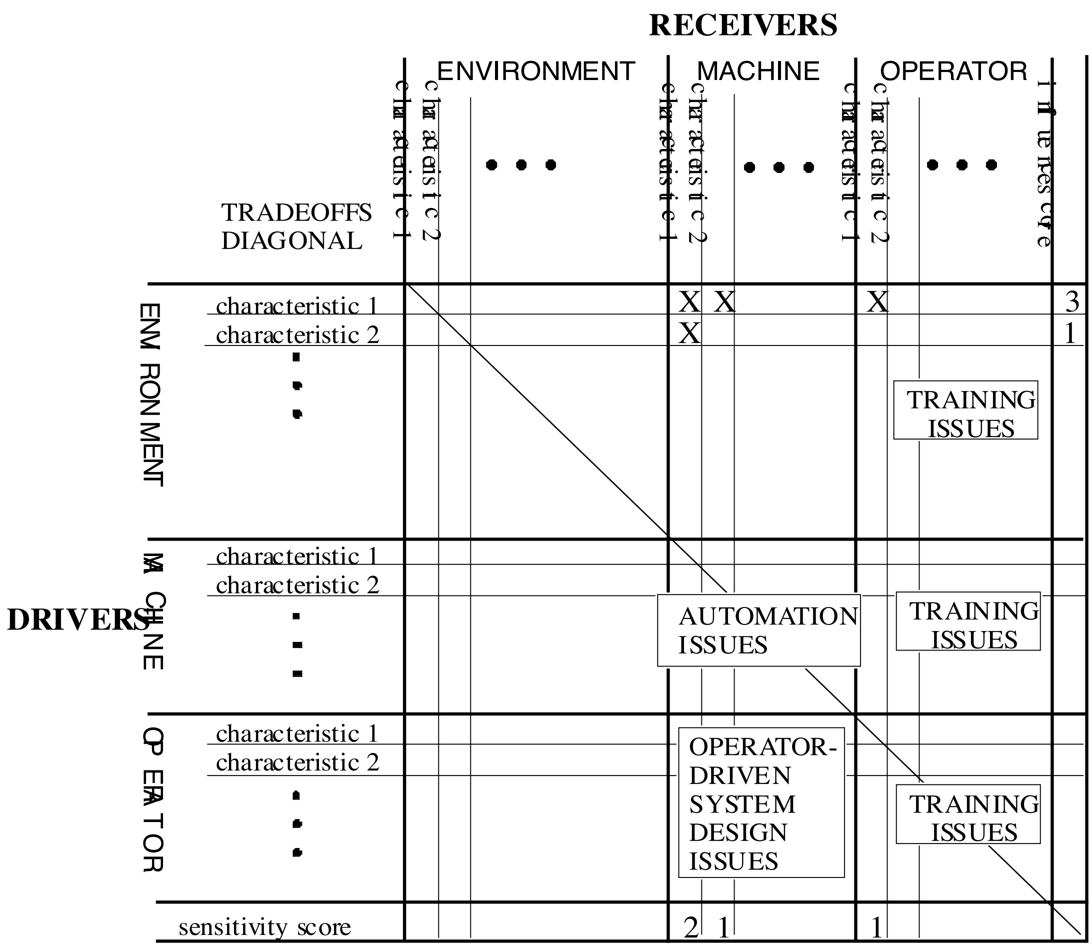


**Table 5.** Classification of issues based on the layout of the matrix (Riley, 1993).

According to this classification scheme, the majority of issues relevant to the SVS system are training issues (66.25%), while relatively few issues appear to be automation issues (9.15%) and operator-driven system design issues (2.97%) (see Table 6).

| | Environment | Operator | Machine | Total Influence |
|---|---|---|---|---|
| Environment | *6.80%* | *Training Issues* *16.81%* | *2.35%* | *25.96%* |
| Operator | *4.82%* | *Training Issues* *23.24%* | *Operator-Driven System Design Issues* *2.97%* | *31.02%* |
| Machine | *7.66%* | *Training Issues* *26.21%* | *Automation Issues* *9.15%* | *43.02%* |
| Total Sensitivity | *19.29%* | *66.25%* | *14.46%* | Total = *100%* |

**Training Issues = *66.25%***
**Automation Issues = *9.15%***
**Operator Driven System Design Issues = *2.97%***
**Most Influential = Machine**
**Most Sensitive = Operator**

**Table 6.** Percentage of interactions found in each section of the matrix.

This classification system suggests that errors within the SVS could be mitigated with proper training. In addition to learning the physical properties and functions of the display, training serves to increase trust in the system and allows the pilot to adopt an accurate mental model of the system, which was found to be a highly sensitive characteristic in step four.

According to the most influential and sensitive characteristics identified earlier, training should assist pilots in gaining experience with the SVS, reducing the level of mental workload, creating an accurate mental model of the environment, creating and accurate machine model, gaining increased SA, and balancing attention appropriately between the out-the-window view, the SVS, and instruments other than the SVS.

It is also important to consider that the category of training issues is comprised of the following interactions: “Environment-Operator”, “Operator-Operator”, and “Machine-Operator” (see Table 6). The largest number of training issues fell into the “Machine-Operator” category (26%). This may suggest that although training with respect to the SVS is important, money may be best spent on display design in order to reduce potential errors in the system. Step four gives specific examples of what aspects of design should be concentrated on when SVS is implemented.

The classification system provided by Riley (1993) also allows one to identify the most influential and sensitive categories (environment, operator, and machine) overall. The current analysis revealed that the “Machine” was the most influential component, while the “Operator” was the most sensitive component. The fact that the machine component is the most influential component of the system is somewhat obvious. This simply implies that the SVS itself has great potential to influence all other components of the system. However, it is less intuitive that the pilot (operator) would be the most sensitive. This implies that other aspects of the SVS and its environment have the potential to seriously influence the pilot. Because the SVS can basically replace the out-the-window view, care must be taken to assure that the pilot is provided with an accurate depiction of the terrain. Also, the GPS must be extremely accurate to assure proper functioning of the system, and that the pilot has an accurate mental model of the environment.

This classification also suggests that it would be most cost-effective if training concentrated on issues and characteristics identified in the “machine” and “operator” categories of the SVS (see Step Four).

Last, as mentioned above, few “Operator-Driven System Design Issues” and “Automation Issues” were identified. This is not surprising because the SVS used for this application had only a moderate level of autonomy (“Information Fuser”) and intelligence (“Personalized”). Therefore, it was not expected that operator characteristics would have a large amount of influence on the SVS used for this analysis.

**Summary**

The SVS that was used for the current analysis was one that incorporated an enhanced view of terrain overlaid with PFD data on a HDD. This system also incorporated either an auditory or visual warning system, three different types of pictorial scene information densities (photo-realistic, less detailed, and wire frame), and could be viewed on three possible display sizes (757 EADI, 777 PFD, or Rectangular Flat Panel). The SVS was also assumed to have four possible FOV ranges from which the pilot could select.

The pilot flying was the main focus of this analysis, although other humans were considered to the extent that they influenced the PF’s actions. Also, only the approach and landing phases of flight were considered in an effort to narrow the analysis. These phases of flight were chosen because of the great potential for error.

The FAIT analysis used in the current research identified basic influential and sensitive components of the SVS environment, as well as tradeoffs between these components, errors within the system, and potential human factors issues.

Using the FAIT method, the system under consideration was labeled as being an “information Fuser” in terms of autonomy. This refers to a system capable of collecting information and putting it in the best format for presentation to the operator. The SVS was also labeled as being “Personalized” in terms of intelligence. This means that the machine uses imbedded models of the operator, and refers to a system that can be personalized to present information in a particular way to the operator.

A number of characteristics were also identified as being highly influential or highly sensitive. After creating a matrix of characteristics of the system, one can compute a relative influence and sensitivity score for each characteristic. Next, only those characteristics, which are highly sensitive and influential, are considered (those which fall above the 80th percentile). This procedure was conducted in two ways. First, highly influential and sensitive characteristics were identified for the system as a whole. Second, highly influential and sensitive characteristics were identified for each component of the system (environment, operator, and machine).

When the system was considered as a whole, only the characteristics “Difficulty of approach/landing” was ranked as both highly influential and highly sensitive. However, when separated by components, the characteristics “Level of mental workload”, “Amount of time spent viewing the SVS display (head-down time)”, “Amount of time spent looking out-the-window (head-up time)”, and “Intuitiveness/usability of the SVS” were identified as being both highly influential and highly sensitive. This suggests that these characteristics are critical to the functioning of the SVS.

Also, 35 potential tradeoff situations were identified, and a scenario was written for each. Because not all characteristics fit the definition of a characteristic identified in step two (something that varies from a desirable to an undesirable state), tradeoff scenarios were separated into those dealing with varying and non-varying characteristics. Each characteristic in the pair for varying characteristics is considered as both a driver and a receiver, and is also considered as both desirable and undesirable. This results in four scenarios for each pair of tradeoff characteristics. In order for a pair to represent a true trade-off relationship, each of the four scenarios must represent a situation in which the characteristics are inversely related.

Because the criteria for identifying true tradeoff relationships is rather stringent, only one was found to represent a true tradeoff situation. However, the type of relationship identified is not as important as the scenario generated for each pair. Also, even pairs that were not labeled as true tradeoff relationships may contain tradeoffs as one or two of the four scenarios. These scenarios identify important human factors issues in the SVS, and can be used as a starting point to identify basic issues and explore more detailed scenarios that are relevant to the system.

Last, error scenarios were written from an abbreviated matrix that contained only highly influential and sensitive characteristics. These scenarios did not incorporate very general characteristics such as "Difficulty of approach/landing" or "Level of mental workload", and are therefore somewhat more specific than the tradeoff scenarios mentioned above.

The majority of issues relevant to the SVS considered for this analysis appear to be training issues (66.25%). This suggested that errors with in the SVS environment could be mitigated with proper training. Specifically, training should assist pilots in gaining experience with the SVS, reducing the level of mental workload, creating an accurate mental model of the environment, creating an accurate machine model, gaining increased SA, and balancing attention appropriately between the out-the-window view, the SVS, and instruments other than the SVS. Because the largest amount of training issues fell into the "Machine-Operator" category, money may be best spent on display design in order to reduce potential errors in the system.

**Future Research**

The present FAIT analysis provided an in-depth analysis of a relatively simple synthetic vision system. Future analyses may wish to examine more complex system that integrates much of the technology that SVS is capable of possessing. Although the current analysis provided a starting point, a FAIT analysis of a more complex system may serve to identify more specific characteristics and human factors issues that are relevant to the SVS. Future research may also benefit from including subject-matter experts, in order to validate the current findings. These subject-matter experts could provide information about the relative importance of characteristics, and the frequency with which they interact with each other.

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## **Preliminary Step:** *Define the components of the SVS system and environment*

1. **The Human:**
   We will be looking only at the pilot flying (PF) with regards to the SVS system. However, pilots of other aircraft, as well as other crew members will occasionally be considered to the extent which they affect the PF.

2. **The Environment:**
   Although the SVS is capable of supporting all phases of flight, we will be focusing only on approach and landing situations using the SVS.

3. **The Machine:**
   We are working with the following SVS system:

## Description of the SVS Used For the Current Analysis:

### Virtual Visual Environment:

- Mimics what could be seen out the window in good visibility conditions
- **Uses either a photo-realistic terrain display, a less detailed terrain texture display, or a wire-frame rendering of terrain
- Display is head-down
- **May have three possible display sizes (757 EADI 5 x 5.25 inch, 777 PFD 6.4 x 6.4 inch, and rectangular flat-panel 8 x 10 inch)
- May have four possible field of views, which are pilot selectable
- PFD symbology is overlaid on the SVS display (this is not selectable)
- Obstacles in proximity of own aircraft are displayed via the terrain database
- Runway edges are depicted
- Salient features are highlighted on the display
- Pilot has the ability to declutter the display
- The SVS will give an auditory or visual warning if impact with terrain is immanent
- The pilot manually enters flight path data into the SVS (or through the FMS)

### Primary Flight Display Information:

- Primary flight display information is overlaid on the SVS display
- Primary flight display information is not redundantly coded elsewhere in the cockpit

- Primary flight display information includes: altitude, airspeed, ground speed, attitude, vertical speed, velocity vector, and location with respect to navigation fixes

** = These are characteristics of the SVS that we are leaving undefined and have the potential to cause three way interactions between characteristics. Each of these SVS characteristics has a corresponding characteristic in the matrix.

## Step #1: Chose the level of autonomy and intelligence of the system in order to create an information flow model

Autonomy: *In order to chose the level of automation, 6 questions were asked of the SVS system. It was determined that the level of automation in **INFORMATION FUSER.***

*1. Does the machine perform any control actions?*

NO. The SVS does not perform any control actions, it simply displays terrain information via the terrain database.

*2. Can the machine manage the operator's displays autonomously?*

NO. In order to answer yes to this question, the SVS would have to be capable of determining what information should be presented, what format it should be presented in, and how it should be presented. It is my understanding that the SVS is not this advanced. It does not determine anything, but simply presents information from a database depending on the position of the aircraft, which is determined by GPS technology.

*3. Can the machine initiate interactions with the operator?*

NO. In order to answer yes to this question, the SVS would have to make recommendations to the operator without being explicitly asked for them. It is my understanding that the SVS does not make any recommendations.

*4. Can the machine provide recommendations or advice?*

NO. Since we are no longer looking at an SVS system that incorporates a sensor, the hazard alerting system would not be present. Therefore, the SVS does not explicitly provide any recommendations to the pilot flying.

*5. Does the machine perform any decision making functions?*

NO. The SVS system does not make any decisions, it simply displays information from the database. In order to answer yes to this question, the SVS would need to perform some type of decision making such as categorization of targets.

*6. Can the machine integrate information and construct displays?*

YES. This would refer to a machine that can collect information and put it in the best format for presentation to the operator. Since the SVS is a simple display, which formats information from a database for presentation to the operator via the display, I think that it fits into this category. Therefore, the SVS is an **INFORMATION FUSER**

**Intelligence:** *In order to determine the level of intelligence, 4 questions were asked of the SVS system. The level of intelligence was determined to be* ***PERSONALIZED****.*

1. Can the machine predict the operator's behavior?

NO. In order to answer yes to this question the SVS would need to be able to collect and use information about the operator's physical state. This is not the case with the SVS.

2. Can the machine monitor the operator's physical state?

NO. The SVS cannot collect or use any information about the physical state of the pilot.

3. Can the machine infer operator intent?

NO. In order to answer yes to this question the SVS would need to be able to dynamically infer the operator's intent and assist the operator in carrying out this intent.

4. Does the machine use imbedded models of the operator?

YES. This refers to a machine, which can be personalized to present information in the particular way that the operator wants it. Since the operator can select FOV the SVS can be personalized in some way. Therefore, the level of intelligence is **PERSONALIZED.**

**Characteristics in Each Node of the Information Flow Chart (Information Fuser/Personalized):**

**The World Node:**
*Everything outside of your particular system, parameters of larger systems that your system fits into should be included*

*What are the important characteristics of the SVS environment (approach and landing), what affects this environment (that is not related to the SVS)?*

Riley states: For enhanced vision, this node would contain parameters for the operational environment and the rest of the airplane, such as engines, the FMS, etc.

- Difficulty of approach
- Difficulty of landing
- Difficult of terrain environment at destination airport
- Traffic situation at destination airport
- Physical state of the engines
- Physical state of the aircraft
- Experience and ability of the pilot
- Pilot experience with this specific approach
- Pilot experience with this specific landing
- Amount of time pilot spent looking out-the-window
- Usability/intuitiveness of displays other than the SVS
- Amount of trust in crew members
- Amount of trust in systems other than the SVS
- Weather
- Degree of time pressure (is aircraft arriving on time, early, or late?)
- Amount of information available from displays other than the SVS
- Glare on displays other than the SVS
- Ceiling visibility at destination airport
- ATC workload
- Functioning/malfunctioning of displays other than the SVS
- Speed of aircraft (too low/high?)
- Altitude of aircraft (too low/high?)

**<u>*The Human Input Quadrant*</u>**

**Perceive World Node:**
*The operators access to information about the operational environment through all methods other than the SVS*

*What affects the pilot's ability to perceive characteristics of the outside environment during takeoff and landing, other that what is being presented on the SVS display?*

- Amount of time spent looking out-the-window
- Experience and ability of the pilot
- Pilot experience with this specific approach
- Pilot experience with this specific landing
- Experience using instruments other than the SVS
- Communication with ATC
- Weather conditions at destination airport
- Ceiling visibility at destination airport
- Amount of time spent reading instruments other than the SVS
- Pilots level of confidence in his/her perception of the world
- Current level of SA
- Accuracy of pilots mental model of the environment
- Amount of noise in cockpit
- Amount of collaboration with crew members
- Accuracy of information from displays other than the SVS
- Amount of information available from displays other than the SVS
- Degree of pilot fatigue

**Perceive Displays Node:**
*Refers to the operators act of reading the displays*

*What affects the pilot's ability to perceive information form the SVS display?*

- Glare on SVS
- Physical condition of display surfaces
- Intuitiveness/usability of the SVS
- Display size
- Pictorial scene information density
- Size of symbols/text
- Color of Terrain
- Color of symbols/text
- Degree of display clutter
- Degree of overlay with PFD data
- Auditory vs. visual warning
- Ability to declutter SVS display
- Number of layers in the menu structure
- Number of key presses required to accesss desired information
- Experience using the SVS
- Pilot experience with this specific approach
- Pilot experience with this specific landing
- Experience with this specific airport

- Experience and ability of the pilot
- Location of the SVS display in the cockpit
- FOV currently depicted on SVS display
- Number of obstacles currently in view
- Number of highlighted features currently in view

**Infer World State Node:**
*The operators process of making sense out of the situation and gaining or maintaining situation awareness*

*What affects the process involved in the pilot's gaining/maintaining situation awareness?*

- Inference delay
- Inference error
- Level of pilot mental workload
- Experience and ability of the pilot
- Accuracy of pilots mental model of the SVS
- Pilots level of confidence in his/her perception of the SVS
- Accuracy of pilots mental model of the SVS
- Degree of time pressure (is aircraft arriving on time, early, or late?)
- Amount of time spent viewing the SVS display
- Amount of time spent reading instruments other than the SVS
- Amount of time spent looking out-the-window
- Number of errors in perceiving SVS data
- Difficulty of approach
- Difficulty of landing
- Pilot experience with this specific approach
- Pilot experience with this specific landing
- Degree of pilot fatigue
- Difficulty of terrain environment at destination airport
- Intuitiveness/usability of the SVS
- Amount of information available from displays other than the SVS
- Functioning/malfunctioning of displays other than the SVS
- Amount of noise in cockpit
- Amount of collaboration with crew members
- Number of highlighted features currently in view
- Accuracy of terrain database

**Infer Machine State Node:**
*Refers to the operator's process of understanding what the machine is doing*

*What affects the pilot's process of understanding what the SVS is doing?*

- Degree of redundant coding of SVS data
- Experience and ability of the pilot
- Amount of time spent viewing the SVS display
- Amount of time spent looking out-the-window
- Intuitiveness/usability of the SVS
- Experience using the SVS
- Degree of display clutter
- Functioning/malfunctioning of displays other than the SVS
- Amount of noise in cockpit
- Current level of SA
- Accuracy of pilots mental model of the SVS
- Pilots level of confidence in his/her perception of the SVS
- Level of mental workload
- Number of errors in perceiving SVS data
- Pilots level of confidence in the accuracy of the SVS
- Amount of display cross-checking

**World Model Node:**
*Represents the operators level of understanding about the operational environment*

*What affects the pilots current mental model of (or awareness of) the SVS environment?*

- Current level of SA
- Amount of time spent viewing the SVS display
- Amount of display cross-checking
- Auditory vs. visual warning
- Pictorial scene information density
- Experience and ability of the pilot
- Pilot experience with this specific approach
- Pilot experience with this specific landing
- Amount of time spent looking out-the-window
- Experience using the SVS
- Intuitiveness/usability of the SVS
- Functioning/malfunctioning of displays other than the SVS
- Number of highlighted features currently in view
- Pilots level of confidence in his/her perception of the world
- Accuracy of pilots mental model of the environment
- Degree of pilot fatigue
- Level of mental workload

**Machine Model Node:**
*Represents the operator's current level of understanding about the system, such as current level of readability.*

*What affects the pilot's current mental model or understanding of the SVS?*

- Accuracy of pilots mental model of the SVS
- Experience using the SVS
- Experience and ability of the pilot
- Degree of redundant coding of SVS data
- Degree of display clutter
- Accuracy of terrain database
- Intuitiveness/usability of the SVS
- Amount of trust in the SVS
- Pilot error when using the SVS
- Number of function keys required to access desired information
- Number of layers in the menu structure

**Machine's Goals Node:**
*Represents the operators understanding of the machines current goals and targets*

*What affects the pilot's ability to understand the goals of the SVS display?*

- Experience and ability of the pilot
- Experience using the SVS
- Pilots level of confidence in the accuracy of the SVS
- Accuracy of pilots mental model of the SVS display
- Intuitiveness/usability of the SVS
- Accuracy of terrain database
- Degree of display clutter
- Amount of time spent viewing the SVS display
- Amount of time spent reading instruments other than the SVS
- Amount of time spent looking out-the-window
- Pilot experience with this specific approach
- Pilot experience with this specific landing
- Experience with terrain surrounding destination airport

**Predict Machine Behavior Node:**
*Refers to the operator's anticipation of the next actions to be taken by the machine*

*What affects the pilot's ability to anticipate the warnings and other behaviors of the SVS display?*

- Accuracy of pilots mental model of the environment

- Accuracy of pilots mental model of the SVS
- Accuracy of terrain database
- Amount of display cross-checking
- Amount of time spent looking out-the-window
- Amount of time spent viewing the SVS display
- Experience using the SVS
- Pilots level of confidence in his/her perception of the SVS
- Level of mental workload
- Degree of pilot fatigue
- Current level of SA
- Pilot experience with this specific approach
- Pilot experience with this specific landing
- Experience with terrain surrounding destination airport
- Experience and ability of the pilot
- Accuracy of information from displays other than the SVS
- Accuracy of GPS
- Intuitiveness/usability of the SVS
- Weather conditions at destination airport
- Amount of noise in cockpit
- Lighting conditions in the cockpit
- Glare on SVS

## ***The Human Output Quadrant***

**Plan Own Action Node:**
*Refers to the operator's process of deciding what to do next*

*What affects the appropriateness (or process) of the action chosen by the pilot?*

- Accuracy of pilots mental model of the environment
- Accuracy of pilots mental model of the SVS
- Pilots level of confidence in his/her perception of the SVS
- Degree of time pressure (is aircraft arriving on time, early, or late?)
- Current level of SA
- Pilots level of confidence in the accuracy of the SVS
- Experience using the SVS
- Experience and ability of the pilot
- Level of self confidence
- Level of mental workload
- Degree of pilot fatigue
- Weather conditions at destination airport
- Traffic situation at destination airport

- Pilot experience with this specific approach
- Pilot experience with this specific landing
- Amount of time spent looking out-the-window
- Amount of display cross-checking
- Intuitiveness/usability of the SVS
- Pilots level of confidence in his/her perception of the world
- Accuracy of terrain database
- Accuracy of GPS
- Difficulty of terrain environment at destination airport

**Operators Goals Node:**
*Represents the operators actual intentions, and can contain characteristics that are the operators counterparts of the "Operators Goals" and "Machines Goals" nodes on the Machine side of the model*

*What affects the operator's actual goals or intentions?*

- Accuracy of pilots mental model of the environment
- Current level of SA
- Experience and ability of the pilot
- Weather conditions at destination airport
- Traffic situation at destination airport
- Difficulty of terrain environment at destination airport

**Self Model Node:**
*Refers to the operators assessment of his or her own current abilities or state*

*What affects the pilot's ability to assess his/her abilities to deal with the current SVS environment?*

- Level of mental workload
- Level of self confidence
- Experience using the SVS
- Level of confidence in the accuracy of the SVS
- Experience and ability of the pilot
- Current level of SA
- Degree of pilot fatigue

**Take No Action or Monitor Node:**
**This is basically a placeholder, and can itself, be listed as a characteristic

**Provide Information Node:**
*Represents the process by which the operator enters data into the system or provides other types of information*

*What affects the pilot's accuracy in providing information data to the SVS (or FMS)?*

- Current level of SA
- Experience and ability of the pilot
- Experience using the SVS (or FMS)
- Accuracy of pilots mental model of the environment
- Level of mental workload
- Accuracy of pilots mental model of the SVS
- Intuitiveness/usability of the SVS (or FMS)

**Request Information Node:**
*Represents the process by which the operator enters requests for information, such as calling up new display pages*
* It is my understanding that the pilot only has the option of selecting FOV from 4 possibilities. Therefore, this is the only request I am referring to in this section.

*What affects the pilot in requesting FOV information from the SVS?*

- Pilot preference
- Proximity to the destination airport
- Experience using the SVS
- Experience and ability of the pilot

**Command Node:**
*Represents inputs made by the operator to change the state of the system through a command to automation*
**Again, right now, the only thing that I think is selectable (can be changed) is the FOV, therefore, I will refer only to this function in this section

*What affects the pilot in commanding the SVS to change FOV?*

- Pilot preference
- Proximity to the destination airport
- Experience using the SVS
- Experience and ability of the pilot

**Control Node:**
*Refers to inputs made by the operators through manual control*

*What affects the pilot in manually entering data concerning flight path into the SVS or FMS?*

- Experience and ability of the pilot
- Experience using the SVS (or FMS)
- Level of mental workload
- Intuitiveness/usability of the SVS (or FMS)
- Number of layers in the menu structure

## ***The Machine Input Quadrant***

**World Sensors Node:**
*This node is intended to contain all the potential sources of information coming into the system (should list characteristics of sensors)*

*How does the SVS receive information, what affects this information (accuracy/quality)?*

- Update rate of Terrain database
- Update rate of GPS
- Accuracy of terrain database
- Accuracy of GPS

**Control Sensors Node:**
*Represents all the ways that the operators can put information into the systems, typically through the controls (should list characteristics of controls)*

*How is information put into the SVS (or FMS), and what affects the accuracy/quality of this information?*

- Accuracy of terrain database
- Accuracy of GPS
- Placement of controls
- Tactile feedback from controls
- Layout of controls
- Feedback delay
- Functioning/malfunctioning of hardware/software
- Number of layers in the menu structure
- Number of key presses required to access desired information
- Force requirements

- Precision requirements
- Format restrictions
- Experience using the SVS (or FMS)
- Experience and ability of the pilot
- Current level of SA
- Accuracy of pilots mental model of the environment
- Level of mental workload
- Accuracy of pilots mental model of the SVS
- Intuitiveness/usability of the SVS (FMS)

**Machines Goals Node:**
*Represents the machines current targets, operational parameters, or understanding of the current mission goals.*

*What affects the ability of the SVS to "understand" which information is relevant to its "role"?*

- Accuracy of terrain database
- Accuracy of the GPS
- Limitations of the machines processor
- Functioning/malfunctioning of hardware/software

**Operator's Goals Node**
*Represents the machines understanding of the operator's current goals.*
**I don't think that this node applies, since the SVS is not capable of inferring, assisting or understanding the operators goals.

**Infer World State Node:**
*Represents the machines process of understanding what the current state of the operational environment is, based on information provided to it from its sensors*

*What affects the processes involved in the SVS gaining/maintaining an understanding of the operational environment?*

- Accuracy of terrain database
- Accuracy of GPS
- Update rate of terrain database
- Update rate of GPS
- Functioning/malfunctioning of hardware/software
- Processing time (to display information from terrain database)

**Operators Models Node:**
*Represents internal representation of the human operator used by the machine to draw inferences about the operator's intention and possible future actions. This node would be relevant to a system that can merely be personalized for a particular operator*

*What affects the ability of the SVS to "understand" what the operator wants personalized? (Note: FOV is the only feature of the SVS that can be personalized)*

- Functioning/malfunctioning of hardware/software

**World Model Node:**
*Represents the machines internal representations of the operational environment*

*What affects the SVS current model of the world?*
***Note: these are the same characteristics as listed under "infer world state node"*

- Accuracy of terrain database
- Accuracy of GPS
- Update rate of terrain database
- Update rate of GPS
- Functioning/malfunctioning of hardware/software
- Processing time (to display data from terrain database)

**<u>*Machine Output Quadrant*</u>**

**Machines Goals Node:**
**See previous "Machines Goals Node" for a list of characteristics

**Construct Displays Node:**
*Refers to the process of taking information to be sent to the crew and generating the display required to do so. It merely represents the process of converting the information available to the system into display formats for the crew.*

*What affects the "ability" of the SVS to process information coming into the system and create a display from that information?*

- Processing time (to display data from terrain database)
- Limitations of the machines processor
- Functioning/malfunctioning of hardware/software
- Update rate of terrain database
- Update rate of GPS

**Displays Node:**
*Refers to the physical display devices*

*What affects the display quality of the information presented by the SVS?*

- Lighting conditions in the cockpit
- Glare on SVS
- Physical condition of display surfaces

**Comprehensive List (Separated by Category):**

**Environment:**
Accuracy of information from displays other than the SVS
Altitude of the aircraft (too low/high?)
Amount of information available from displays other than the SVS
Amount of noise in cockpit
ATC workload
Ceiling visibility at destination airport
Degree of redundant coding of SVS data
Degree of time pressure (is aircraft arriving on time, early, or late?)
Difficulty of approach
Difficulty of landing
Difficulty of terrain environment at destination airport
Functioning/malfunctioning of displays other than the SVS
Glare on displays other than the SVS
Lighting conditions in the cockpit
Physical state of the aircraft
Physical state of the engines
Speed of aircraft (too low/high?)
Traffic situation at destination airport
Usability/intuitiveness of displays other than the SVS
Weather conditions at destination airport

**Pilot:**
Accuracy of pilots mental model of the environment
Accuracy of pilots mental model of the SVS
Amount of collaboration with crew members
Amount of display cross-checking
Amount of time spent looking out-the-window
Amount of time spent reading instruments other than the SVS
Amount of time spent viewing the SVS display
Amount of trust in crew members
Amount of trust in SVS
Amount of trust in systems other than the SVS

Current level of SA
Degree of pilot fatigue
Experience and ability of the pilot
Experience using the SVS
Experience with terrain surrounding destination airport
Inference delay
Inference error
Level of mental workload
Level of self confidence
Number of errors in perceiving SVS data
Pilot error when using the SVS
Pilot experience with this specific approach
Pilot experience with this specific landing
Pilot preference
Pilots level of confidence in his/her perception of the SVS
Pilots level of confidence in his/her perception of the world
Pilots level of confidence in the accuracy of the SVS
Proximity to the destination airport

**Machine:**
Ability to declutter SVS display
Accuracy of GPS
Accuracy of terrain database
Auditory vs. visual warning
Color of symbols/text
Color of terrain
Degree of display clutter
Degree of overlay with PFD data
Display size
Feedback delay
FOV currently depicted on the SVS display
Functioning/malfunctioning of hardware/software
Glare on SVS
Intuitiveness/usability of the SVS
Layout of controls
Limitations of the machines processor
Location of the SVS display in the cockpit
Number of errors in perceiving SVS data
Number of highlighted features currently in view
Number of key presses required to access desired information
Number of layers in menu structure
Number of obstacles currently in view
Physical condition of display surfaces
Pictorial scene information density
Placement of controls
Processing time (to display data from terrain database)

Size of symbols/text
Tactile feedback from controls
Update rate of GPS
Update rate of terrain database

## Appendix C

| | Drivers \ Receivers | Accuracy of information from displays other than the SVS | Altitude of the aircraft (too low/high?) | Amount of information available from displays other than SVS | Amount of noise in the cockpit | ATC workload | Ceiling visibility at destination airport | Degree of redundant coding of SVS data | Degree of time pressure | Difficulty of approach | Difficulty of landing | Difficulty of terrain enviro | Functioning/mal | Glare |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Environment** | Accuracy of information from displays other than the SVS | | 1 | | | | | | 1 | 1 | 1 | | | |
| | Altitude of the aircraft (too low/high?) | | | | | 1 | | | | 1 | 1 | | | |
| | Amount of information available from displays other than SVS | | | | | | | | | 1 | 1 | | | |
| | Amount of noise in cockpit | | | | | | | | | | | | | |
| | ATC workload | | | | | | | | | | | | | |
| | Ceiling visibility at destination airport | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Degree of redundant coding of SVS data | | | | | | | | | | | | | |
| | Degree of time pressure | | | | | 1 | | | | 1 | 1 | | | |
| | Difficulty of approach | | | | | 1 | | | | | 1 | | | |
| | Difficulty of landing | | | | | 1 | | | | | | | | |
| | Difficulty of terrain environment at destination airport | | 1 | | | | | | | 1 | 1 | | | |
| | Functioning/malfunctioning of displays other than the SVS | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Glare on displays other than the SVS | | | | | | | | | 1 | 1 | | | |
| | Lighting conditions in the cockpit | | | | | | | | | | | | | 1 |

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| | Physical state of the aircraft | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Physical state of the engines | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Speed of aircraft (too low/high?) | | | | | 1 | | | | 1 | 1 | | | |
| | Traffic situation at destination airport | | | | | 1 | | | | 1 | 1 | | | |
| | Usability/intuitiveness of displays other than the SVS | | | | | | | | | 1 | 1 | | | |
| | Weather conditions at destination airport | | 1 | | | 1 | | | | 1 | 1 | | | |
| **Pilot** | Accuracy of pilots mental model of the environment | | | | | | | | | 1 | 1 | | | |
| | Accuracy of pilots mental model of the SVS | | | | | | | | | 1 | 1 | | | |
| | Amount of collaboration with crew members | | | | | | | | | 1 | 1 | | | |
| | Amount of display cross-checking | | | | | | | | | 1 | 1 | | | |
| | Amount of time spent looking out-the-window | | | | | | | | | 1 | 1 | | | |
| | Amount of time spent reading instruments other than the SVS | | | | | | | | | 1 | 1 | | | |
| | Amount of time spent viewing the SVS display | | | | | | | | | 1 | 1 | | | |
| | Amount of trust in crew members | | | | | | | | | 1 | 1 | | | |
| | Amount of trust in SVS | | | | | | | | | | | | | |
| | Amount of trust in systems other than the SVS | | | | | | | | | | | | | |
| | Current level of SA | | | | | | | | | 1 | 1 | | | |
| | Degree of pilot fatigue | | | | | | | | | 1 | 1 | | | |
| | Experience and ability of the pilot | | | | | 1 | | | | 1 | 1 | | | |
| | Experience using the SVS | | | | | | | | | 1 | 1 | | | |
| | Experience with terrain surrounding destination airport | | | | | | | | | 1 | 1 | | | |
| | Inference delay | | | | | | | | | | | | | |
| | Inference error | | | | | | | | | 1 | 1 | | | |
| | Level of mental workload | | | | | | | | | 1 | 1 | | | |
| | Level of self confidence | | | | | | | | | | | | | |
| | Number of errors in perceiving SVS data | | | | | | | | | 1 | 1 | | | |
| | Pilot error when using the SVS | | | | | | | | | 1 | 1 | | | |
| | Pilot experience with this specific approach | | | | | | | | | 1 | 1 | | | |
| | Pilot experience with this specific landing | | | | | | | | | 1 | 1 | | | |
| | Pilot preference | | | | | | | | | | | | | |
| | Pilots level of confidence in his/her perception of the SVS | | | | | | | | | | | | | |
| | Pilots level of confidence in his/her perception of the world | | | | | | | | | | | | | |
| | Pilots level of confidence in the accuracy of the SVS | | | | | | | | | | | | | |
| | Proximity to the destination airport | | | | | | | | | | | | | |
| **Machine** | Ability to declutter SVS display | | | | | | | | | 1 | 1 | | | |

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| Accuracy of GPS | | 1 | | | 1 | | | | 1 | 1 | | | |
| Accuracy of terrain database | | 1 | | | 1 | | | | 1 | 1 | | | |
| Auditory vs. visual warning | | | | | | | | | 1 | 1 | | | |
| Color of symbols/text | | | | | | | | | 1 | 1 | | | |
| Color of terrain | | | | | | | | | 1 | 1 | | | |
| Degree of display clutter | | | | | | | | | 1 | 1 | | | |
| Degree of overlay with PFD data | | | | | | | | | 1 | 1 | | | |
| Display size | | | | | | | | | 1 | 1 | | | |
| Feedback delay | | | | | | | | | 1 | 1 | | | |
| FOV currently depicted on the SVS display | | | | | | | | | 1 | 1 | | | |
| Functioning/malfunctioning of hardware/software | | | | | | | | | 1 | 1 | | | |
| Glare on SVS | | | | | | | | | 1 | 1 | | | |
| Intuitiveness/usability of the SVS | | | | | | | | | 1 | 1 | | | |
| Layout of controls | | | | | | | | | 1 | 1 | | | |
| Limitations of the machines processor | | | | | | | | | 1 | 1 | | | |
| Location of the SVS display in the cockpit | | | | | | | | | 1 | 1 | | | |
| Number of highlighted features currently in view | | | | | | | | | 1 | 1 | | | |
| Number of key presses required to access desired information | | | | | | | | | 1 | 1 | | | |
| Number of layers in menu structure | | | | | | | | | 1 | 1 | | | |
| Number of obstacles currently in view | | | | | | | | | 1 | 1 | | | |
| Physical condition of display surfaces | | | | | | | | | 1 | 1 | | | |
| Pictorial scene information density | | | | | | | | | 1 | 1 | | | |
| Placement of controls | | | | | | | | | 1 | 1 | | | |
| Processing time (to display data from terrain database) | | | | | | | | | 1 | 1 | | | |
| Size of symbols/text | | | | | | | | | 1 | 1 | | | |
| Tactile feedback from controls | | | | | | | | | | | | | |
| Update rate of GPS | | | | | | | | | 1 | 1 | | | |
| Update rate of terrain database | | | | | | | | | 1 | 1 | | | |
| **SENSITIVITY TOTAL** | 0 | 9 | 0 | 0 | 14 | 0 | 0 | 1 | 61 | 62 | 0 | 0 | 1 |
| **SENSITIVITY RANK (2)** | 63 | 23.5 | 63 | 63 | 17.5 | 63 | 63 | 45 | 3 | 2 | 63 | 63 | 45 |

...ronment at destination airport
...alfunctioning of displays other than the SVS
...e on displays other than the SVS

| Environment | | | | | | | Pilot | | | | | | | | | | | | | | | | | | | | | |
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| Lighting conditions in the cockpit | Physical state of the aircraft | Physical state of the engines | Speed of the aircraft (too low/high?) | Traffic situation at destination airport | Usability/intuitiveness of displays other than the SVS | Weather conditions at destination airport | Accuracy of pilots mental model of the environment | Accuracy of pilots mental model fo the SVS | Amount of collaboration with crew members | Amount of display cross-checking | Amount of time spent looking out-the-window | Amount of time spent reading instruments other than the SVS | Amount of time spent viewing the SVS display | Amount of trust in crew members | Amount of trust in SVS | Amount of trust in systems other than the SVS | Current level of SA | Degree of pilot fatigue | Experience and ability of the pilot | Experience using the SVS | Experience with terrain surrounding destination airport | Inference delay | Inference error | Level of mental workload | Level of self confidence | Number of errors in percei... | Pilot error when ... | Pilot ... |
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...eiving SVS data

...n using the SVS

...t experience with this specific approach

**Machine**

| Pilot expericence with this specific landing | Pilot preference | Pilots level of confidence in his/her perception of the SVS | Pilots level of confidence in his/her perception of the world | Pilots level of confidence in the accuracy of the SVS | Proximity to destination airport | Ability to declutter SVS display | Accuracy of GPS | Accuracy of terrain database | Auditory vs. visual warning | Color of symbols/text | Color of terrain | Degree of display clutter | Degree of overlay with PFD data | Display size | Feedback delay | FOV currently depicted on the SVS display | Functioning/malfunctioning of hardware/software | Glare on SVS | Intuitiveness/usability of the SVS | Layout of controls | Limiations of the machines processor | Location of the SVS display | Number of highlighted features currently in view | Number of key presses required to access desired… | Number of layers in menu structure | Number of obstacles curren… | Physical conditi… | Pictori… |
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| 0 | 0 | 14 | 21 | 15 | 0 | 0 | 0 | 0 | 9 | 6 | 6 | 11 | 11 | 9 | 4 | 6 | 0 | 0 | 31 | 4 | 0 | 4 | 0 | 2 | 1 | 1 | 0 | 5 |
| 63 | 63 | 17.5 | 14 | 16 | 63 | 63 | 63 | 63 | 23.5 | 30 | 30 | 19.5 | 19.5 | 23.5 | 35.5 | 30 | 63 | 63 | 11 | 35.5 | 63 | 35.5 | 63 | 40 | 45 | 45 | 63 | 32.5 |

ed information
ently in view
tion of display surfaces
orial scene information density

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Placement of controls | | | | | | | | | | | | | | | |
| Processing time (to display data from terrain database) | | | | | | | | | | | | | | | |
| Size of symbols/text | | | | | | | | | | | | | | | |
| Tactile feedback from controls | | | | | | | | | | | | | | | |
| Update rate of GPS | | | | | | | | | | | | | | | |
| Update rate of terrain database | | | | | | | | | | | | | | | |
| **INFLUENCE TOTAL** | | 15 | 4 | 12 | 4 | 0 | 14 | 14 | 13 | 20 | 19 | 24 | 17 | 7 | 1 |
| **INFLUENCE (2)** | | 16.5 | 69.5 | 30.5 | 69.5 | 77 | 22.5 | 22.5 | 27.5 | 5 | 7 | 2 | 9.5 | 53 | 75.5 |

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| | | | | | | 8 | 48 |
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| | | | | | | 4 | 69.5 |
| | | | | | | 5 | 64 |
| | | | | | | 7 | 53 |
| | | | | | | 14 | 22.5 |
| | | | | | | 6 | 58.5 |
| | | | | | | 8 | 48 |
| | | | | | | 5 | 64 |
| | | | | | | 15 | 16.5 |
| | | | | | | 15 | 16.5 |
| | | | | | | 9 | 41.5 |
| | | | | | | 15 | 16.5 |
| | | | | | | 3 | 73.5 |
| | | | | | | 7 | 53 |
| | | | | | | 4 | 69.5 |
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| | | | | | | 11 | 33.5 |
| | | | | | | 11 | 33.5 |
| 1 | | 1 | | | | 17 | 9.5 |
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| | | | | | | 7 | 53 |
| | | | | | | 6 | 58.5 |
| | | | | | | 5 | 64 |

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| | | | | | | 12 | 30.5 |
| | | | | | | 14 | 22.5 |
| | | | | | | 15 | 16.5 |
| | | 1 | | | | 14 | 22.5 |
| | | | | | | 10 | 36.5 |
| | | | | | | 5 | 64 |
| | | | | | | 13 | 27.5 |
| | | | | | | 16 | 12.5 |
| 1 | | 1 | 1 | | | 30 | 1 |
| | | | | | | 7 | 53 |
| | 1 | | | | | 17 | 9.5 |
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| | | | | | | 6 | 58.5 |
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| | | | | | | 3 | 73.5 |
| | | | | | | 9 | 41.5 |
| | | | | | | 9 | 41.5 |
| 2 | 1 | 3 | 1 | 0 | 0 | | |
| 40 | 45 | 38 | 45 | 63 | 63 | | |

| | INFLUENCE TOTALS | SCORE | RANK | RANK (2) |
|---|---|---|---|---|
| m | Intuitiveness/usability of the SVS | 30 | 1 | 1 |
| w | Difficulty of terrain environment at destination airport | 24 | 2 | 2 |
| p | Experience and ability of the pilot | 22 | 3 | 3 |
| w | Difficulty of approach | 20 | 4 | 5 |
| m | Accuracy of GPS | 20 | 4 | 5 |
| m | Accuracy of terrain database | 20 | 4 | 5 |
| w | Difficulty of landing | 19 | 7 | 7 |
| w | Functioning/malfunctioning of displays other than the SVS | 17 | 8 | 9.5 |
| p | Pilot preference | 17 | 8 | 9.5 |
| m | Limitations of the machines processor | 17 | 8 | 9.5 |
| m | Pictorial scene information density | 17 | 8 | 9.5 |
| p | Experience using the SVS | 16 | 12 | 12.5 |
| m | Glare on SVS | 16 | 12 | 12.5 |
| w | Accuracy of information from displays other than the SVS | 15 | 14 | 16.5 |
| p | Amount of display cross-checking | 15 | 14 | 16.5 |
| p | Amount of time spent looking out-the-window | 15 | 14 | 16.5 |
| p | Amount of time spent viewing the SVS display | 15 | 14 | 16.5 |
| p | Level of mental workload | 15 | 14 | 16.5 |
| m | Degree of overlay with PFD data | 15 | 14 | 16.5 |
| w | Ceiling visibility at destination airport | 14 | 20 | 22.5 |
| w | Degree of redundant coding of SVS data | 14 | 20 | 22.5 |
| w | Weather conditions at destination airport | 14 | 20 | 22.5 |
| m | Color of symbols/text | 14 | 20 | 22.5 |
| m | Degree of display clutter | 14 | 20 | 22.5 |
| m | Display size | 14 | 20 | 22.5 |
| w | Degree of time pressure (is aircraft arriving on time, early) | 13 | 26 | 27.5 |
| m | Auditory vs. visual warning | 13 | 26 | 27.5 |
| m | Functioning/malfunctioning of hardware/software | 13 | 26 | 27.5 |
| m | Physical condition of display surfaces | 13 | 26 | 27.5 |
| w | Amount of information available from displays other SVS | 12 | 30 | 30.5 |
| m | Color of terrain | 12 | 30 | 30.5 |
| p | Experience with terrain surrounding destination airport | 11 | 32 | 33.5 |
| p | Pilot experience with this specific approach | 11 | 32 | 33.5 |
| p | Pilot experience with this specific landing | 11 | 32 | 33.5 |
| m | Number of layers in menu structure | 11 | 32 | 33.5 |
| m | Feedback delay | 10 | 36 | 36.5 |
| m | Processing time (to display data from terrain database) | 10 | 36 | 36.5 |
| p | Amount of time spent reading instruments other than the SVS | 9 | 38 | 41.5 |
| m | Location of the SVS display in the cockpit | 9 | 38 | 41.5 |
| m | Number of highlighted features currently in view | 9 | 38 | 41.5 |

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|---|---|---|---|---|
| m | Number of obstacles currently in view | 9 | 38 | 41.5 |
| m | Placement of controls | 9 | 38 | 41.5 |
| m | Size of symbols/text | 9 | 38 | 41.5 |
| m | Update rate of GPS | 9 | 38 | 41.5 |
| m | Update rate of terrain database | 9 | 38 | 41.5 |
| w | Physical state of the aircraft | 8 | 46 | 48 |
| w | Physical state of the engines | 8 | 46 | 48 |
| p | Accuracy of pilots mental model of the SVS | 8 | 46 | 48 |
| p | Current level of SA | 8 | 46 | 48 |
| p | Degree of pilot fatigue | 8 | 46 | 48 |
| w | Glare on displays other than the SVS | 7 | 51 | 53 |
| w | Usability/intuitiveness of displays other than the SVS | 7 | 51 | 53 |
| p | Amount of trust in SVS | 7 | 51 | 53 |
| p | Pilots level of confidence in the accuracy of the SVS | 7 | 51 | 53 |
| m | Layout of controls | 7 | 51 | 53 |
| p | Accuracy of pilots mental model of the environment | 6 | 56 | 58.5 |
| p | Inference error | 6 | 56 | 58.5 |
| p | Number of errors in perceiving SVS data | 6 | 56 | 58.5 |
| p | Pilot error when using the SVS | 6 | 56 | 58.5 |
| p | Proximity to the destination airport | 6 | 56 | 58.5 |
| m | Number of key presses required to access desired information | 6 | 56 | 58.5 |
| w | Traffic situation at destination airport | 5 | 62 | 64 |
| p | Amount of collaboration with crew members | 5 | 62 | 64 |
| p | Level of self confidence | 5 | 62 | 64 |
| m | Ability to declutter SVS display | 5 | 62 | 64 |
| m | FOV currently depicted on the SVS display | 5 | 62 | 64 |
| w | Altitude of the aircraft (too low/high?) | 4 | 67 | 69.5 |
| w | Amount of noise in cockpit | 4 | 67 | 69.5 |
| w | Speed of aircraft (too low/high?) | 4 | 67 | 69.5 |
| p | Amount of trust in systems other than the SVS | 4 | 67 | 69.5 |
| p | Pilots level of confidence in his/her perception of the SVS | 4 | 67 | 69.5 |
| p | Pilots level of confidence in his/her perception of the world | 4 | 67 | 69.5 |
| p | Amount of trust in crew members | 3 | 73 | 73.5 |
| m | Tactile feedback from controls | 3 | 73 | 73.5 |
| w | Lighting conditions in the cockpit | 1 | 75 | 75.5 |
| p | Inference delay | 1 | 75 | 75.5 |
| w | ATC workload | 0 | 77 | 77 |

| | SENSITIVITY TOTALS | SCORE | RANK | RANK (2) |
|---|---|---|---|---|
| m | Level of mental workload | 63 | 1 | 1 |
| m | Difficulty of landing | 62 | 2 | 2 |
| m | Difficulty of approach | 61 | 3 | 3 |
| m | Amount of time spent reading instruments other than the SVS | 52 | 4 | 4 |
| m | Amount of time spent viewing the SVS display | 51 | 5 | 5 |
| m | Current level of SA | 46 | 6 | 6 |
| m | Accuracy of pilots mental model of the environment | 44 | 7 | 7 |
| m | Amount of time spent looking out-the-window | 43 | 8 | 8 |
| m | Number of errors in perceiving SVS data | 32 | 9 | 9 |
| m | Intuitiveness/usability of the SVS | 31 | 10 | 11 |
| m | Accuracy of pilots mental model of the SVS | 31 | 10 | 11 |
| m | Pilot error when using the SVS | 31 | 10 | 11 |
| m | Amount of display cross-checking | 28 | 13 | 13 |
| m | Pilots level of confidence in his/her perception of the world | 21 | 14 | 14 |
| m | Level of self confidence | 18 | 15 | 15 |
| m | Pilots level of confidence in the accuracy of the SVS | 15 | 16 | 16 |
| m | Pilots level of confidence in his/her perception of the SVS | 14 | 17 | 17.5 |
| m | ATC workload | 14 | 17 | 17.5 |
| m | Degree of display clutter | 11 | 19 | 19.5 |
| m | Degree of overlay with PFD data | 11 | 19 | 19.5 |
| m | Auditory vs. visual warning | 9 | 21 | 23.5 |
| m | Display size | 9 | 21 | 23.5 |
| m | Inference delay | 9 | 21 | 23.5 |
| m | Inference error | 9 | 21 | 23.5 |
| m | Altitude of the aircraft (too low/high?) | 9 | 21 | 23.5 |
| m | Speed of aircraft (too low/high?) | 9 | 21 | 23.5 |
| m | Amount of trust in SVS | 8 | 27 | 27.5 |
| m | Degree of pilot fatigue | 8 | 27 | 27.5 |
| m | Color of symbols/text | 6 | 29 | 30 |
| p | Color of terrain | 6 | 29 | 30 |
| p | FOV currently depicted on the SVS display | 6 | 29 | 30 |
| p | Pictorial scene information density | 5 | 32 | 32.5 |
| p | Amount of trust in systems other than the SVS | 5 | 32 | 32.5 |
| p | Feedback delay | 4 | 34 | 35.5 |
| p | Layout of controls | 4 | 34 | 35.5 |
| p | Location of the SVS display in the cockpit | 4 | 34 | 35.5 |
| p | Amount of collaboration with crew members | 4 | 34 | 35.5 |
| p | Size of symbols/text | 3 | 38 | 38 |
| p | Number of key presses required to access desired information | 2 | 39 | 40 |
| p | Placement of controls | 2 | 39 | 40 |

| | | | | |
|---|---|---|---|---|
| p | Experience using the SVS | 2 | 39 | 40 |
| p | Number of layers in menu structure | 1 | 42 | 45 |
| p | Number of obstacles currently in view | 1 | 42 | 45 |
| p | Processing time (to display data from terrain database) | 1 | 42 | 45 |
| p | Tactile feedback from controls | 1 | 42 | 45 |
| p | Amount of trust in crew members | 1 | 42 | 45 |
| p | Degree of time pressure (is aircraft arriving on time, early) | 1 | 42 | 45 |
| p | Glare on displays other than the SVS | 1 | 42 | 45 |
| p | Ability to declutter SVS display | 0 | 49 | 63 |
| p | Accuracy of GPS | 0 | 49 | 63 |
| p | Accuracy of terrain database | 0 | 49 | 63 |
| p | Functioning/malfunctioning of hardware/software | 0 | 49 | 63 |
| p | Glare on SVS | 0 | 49 | 63 |
| p | Limitations of the machines processor | 0 | 49 | 63 |
| p | Number of highlighted features currently in view | 0 | 49 | 63 |
| p | Physical condition of display surfaces | 0 | 49 | 63 |
| p | Update rate of GPS | 0 | 49 | 63 |
| w | Update rate of terrain database | 0 | 49 | 63 |
| w | Experience and ability of the pilot | 0 | 49 | 63 |
| w | Experience with terrain surrounding destination airport | 0 | 49 | 63 |
| w | Pilot experience with this specific approach | 0 | 49 | 63 |
| w | Pilot experience with this specific landing | 0 | 49 | 63 |
| w | Pilot preference | 0 | 49 | 63 |
| w | Proximity to the destination airport | 0 | 49 | 63 |
| w | Accuracy of information from displays other than the SVS | 0 | 49 | 63 |
| w | Amount of information available from displays other SVS | 0 | 49 | 63 |
| w | Amount of noise in cockpit | 0 | 49 | 63 |
| w | Ceiling visibility at destination airport | 0 | 49 | 63 |
| w | Degree of redundant coding of SVS data | 0 | 49 | 63 |
| w | Difficulty of terrain environment at destination airport | 0 | 49 | 63 |
| w | Functioning/malfunctioning of displays other than the SVS | 0 | 49 | 63 |
| w | Lighting conditions in the cockpit | 0 | 49 | 63 |
| w | Physical state of the aircraft | 0 | 49 | 63 |
| w | Physical state of the engines | 0 | 49 | 63 |
| w | Traffic situation at destination airport | 0 | 49 | 63 |
| w | Usability/intuitiveness of displays other than the SVS | 0 | 49 | 63 |
| w | Weather conditions at destination airport | 0 | 49 | 63 |

| INFLUENCE TOTALS | SCORE | RANK | RANK (2) |
| --- | --- | --- | --- |
| **Environment** | | | |
| Difficulty of terrain environment at destination airport | 24 | 2 | 2 |
| Difficulty of approach | 20 | 4 | 5 |
| Difficulty of landing | 19 | 7 | 7 |
| Functioning/malfunctioning of displays other than the SVS | 17 | 8 | 9.5 |
| Accuracy of information from displays other than the SVS | 15 | 14 | 16.5 |
| Ceiling visibility at destination airport | 14 | 20 | 22.5 |
| Degree of redundant coding of SVS data | 14 | 20 | 22.5 |
| Weather conditions at destination airport | 14 | 20 | 22.5 |
| Degree of time pressure (is aircraft arriving on time, early) | 13 | 26 | 27.5 |
| Amount of information available from displays other SVS | 12 | 30 | 30.5 |
| Physical state of the aircraft | 8 | 46 | 48 |
| Physical state of the engines | 8 | 46 | 48 |
| Glare on displays other than the SVS | 7 | 51 | 53 |
| Usability/intuitiveness of displays other than the SVS | 7 | 51 | 53 |
| Traffic situation at destination airport | 5 | 62 | 64 |
| Altitude of the aircraft (too low/high?) | 4 | 67 | 69.5 |
| Amount of noise in cockpit | 4 | 67 | 69.5 |
| Speed of aircraft (too low/high?) | 4 | 67 | 69.5 |
| Lighting conditions in the cockpit | 1 | 75 | 75.5 |
| ATC workload | 0 | 77 | 77 |
| **Pilot** | | | |
| Experience and ability of the pilot | 22 | 3 | 3 |
| Pilot preference | 17 | 8 | 9.5 |
| Experience using the SVS | 16 | 12 | 12.5 |
| Amount of display cross-checking | 15 | 14 | 16.5 |
| Amount of time spent looking out-the-window | 15 | 14 | 16.5 |
| Amount of time spent viewing the SVS display | 15 | 14 | 16.5 |
| Level of mental workload | 15 | 14 | 16.5 |
| Experience with terrain surrounding destination airport | 11 | 32 | 33.5 |
| Pilot experience with this specific approach | 11 | 32 | 33.5 |
| Pilot experience with this specific landing | 11 | 32 | 33.5 |
| Amount of time spent reading instruments other than the S | 9 | 38 | 41.5 |
| Accuracy of pilots mental model of the SVS | 8 | 46 | 48 |
| Current level of SA | 8 | 46 | 48 |
| Degree of pilot fatigue | 8 | 46 | 48 |
| Amount of trust in SVS | 7 | 51 | 53 |
| Pilots level of confidence in the accuracy of the SVS | 7 | 51 | 53 |
| Accuracy of pilots mental model of the environment | 6 | 56 | 58.5 |

| | | | |
|---|---|---|---|
| Inference error | 6 | 56 | 58.5 |
| Number of errors in perceiving SVS data | 6 | 56 | 58.5 |
| Pilot error when using the SVS | 6 | 56 | 58.5 |
| Proximity to the destination airport | 6 | 56 | 58.5 |
| Amount of collaboration with crew members | 5 | 62 | 64 |
| Level of self confidence | 5 | 62 | 64 |
| Amount of trust in systems other than the SVS | 4 | 67 | 69.5 |
| Pilots level of confidence in his/her perception of the SVS | 4 | 67 | 69.5 |
| Pilots level of confidence in his/her perception of the world | 4 | 67 | 69.5 |
| Amount of trust in crew members | 3 | 73 | 73.5 |
| Inference delay | 1 | 75 | 75.5 |
| **Machine** | | | |
| Intuitiveness/usability of the SVS | 30 | 1 | 1 |
| Accuracy of GPS | 20 | 4 | 5 |
| Accuracy of terrain database | 20 | 4 | 5 |
| Limitations of the machines processor | 17 | 8 | 9.5 |
| Pictorial scene information density | 17 | 8 | 9.5 |
| Glare on SVS | 16 | 12 | 12.5 |
| Degree of overlay with PFD data | 15 | 14 | 16.5 |
| Color of symbols/text | 14 | 20 | 22.5 |
| Degree of display clutter | 14 | 20 | 22.5 |
| Display size | 14 | 20 | 22.5 |
| Auditory vs. visual warning | 13 | 26 | 27.5 |
| Functioning/malfunctioning of hardware/software | 13 | 26 | 27.8 |
| Physical condition of display surfaces | 13 | 26 | 27.8 |
| Color of terrain | 12 | 30 | 30.5 |
| Number of layers in menu structure | 11 | 32 | 33.5 |
| Feedback delay | 10 | 36 | 36.5 |
| Processing time (to display data from terrain database) | 10 | 36 | 36.5 |
| Location of the SVS display in the cockpit | 9 | 38 | 41.5 |
| Number of highlighted features currently in view | 9 | 38 | 41.5 |
| Number of obstacles currently in view | 9 | 38 | 41.5 |
| Placement of controls | 9 | 38 | 41.5 |
| Size of symbols/text | 9 | 38 | 41.5 |
| Update rate of GPS | 9 | 38 | 41.5 |
| Update rate of terrain database | 9 | 38 | 41.5 |
| Layout of controls | 7 | 51 | 53 |
| Number of key presses required to access desired informati | 6 | 56 | 58.5 |
| Ability to declutter SVS display | 5 | 62 | 64 |
| FOV currently depicted on the SVS display | 5 | 62 | 64 |
| Tactile feedback from controls | 3 | 73 | 73.5 |

| SENSITIVITY TOTALS | SCORE | RANK | RANK (2) |
| --- | --- | --- | --- |
| Environment | | | |
| Difficulty of approach | 61 | 3 | 3 |
| ATC workload | 14 | 17 | 17.5 |
| Altitude of the aircraft (too low/high?) | 9 | 21 | 23.5 |
| Speed of aircraft (too low/high?) | 9 | 21 | 23.5 |
| Degree of time pressure (is aircraft arriving on time, early) | 1 | 42 | 45 |
| Glare on displays other than the SVS | 1 | 42 | 45 |
| Accuracy of information from displays other than the SVS | 0 | 49 | 63 |
| Amount of information available from displays other SVS | 0 | 49 | 63 |
| Amount of noise in cockpit | 0 | 49 | 63 |
| Ceiling visibility at destination airport | 0 | 49 | 63 |
| Degree of redundant coding of SVS data | 0 | 49 | 63 |
| Difficulty of terrain environment at destination airport | 0 | 49 | 63 |
| Functioning/malfunctioning of displays other than the SVS | 0 | 49 | 63 |
| Lighting conditions in the cockpit | 0 | 49 | 63 |
| Physical state of the aircraft | 0 | 49 | 63 |
| Physical state of the engines | 0 | 49 | 63 |
| Traffic situation at destination airport | 0 | 49 | 63 |
| Usability/intuitiveness of displays other than the SVS | 0 | 49 | 63 |
| Weather conditions at destination airport | 0 | 49 | 63 |
| Pilot | | | |
| Level of mental workload | 63 | 1 | 1 |
| Amount of time spent reading instruments other than the S | 52 | 4 | 4 |
| Amount of time spent viewing the SVS display | 51 | 5 | 5 |
| Current level of SA | 46 | 6 | 6 |
| Accuracy of pilots mental model of the environment | 44 | 7 | 7 |
| Amount of time spent looking out-the-window | 43 | 8 | 8 |
| Number of errors in perceiving SVS data | 32 | 9 | 9 |
| Accuracy of pilots mental model of the SVS | 31 | 10 | 11 |
| Pilot error when using the SVS | 31 | 10 | 11 |
| Amount of display cross-checking | 28 | 13 | 13 |
| Pilots level of confidence in his/her perception of the world | 21 | 14 | 14 |
| Level of self confidence | 18 | 15 | 15 |
| Pilots level of confidence in the accuracy of the SVS | 15 | 16 | 16 |
| Pilots level of confidence in his/her perception of the SVS | 14 | 17 | 17.5 |
| Inference delay | 9 | 21 | 23.5 |
| Inference error | 9 | 21 | 23.5 |
| Amount of trust in SVS | 8 | 27 | 27.5 |

| | | | |
|---|---|---|---|
| Degree of pilot fatigue | 8 | 27 | 27.5 |
| Amount of trust in systems other than the SVS | 5 | 32 | 32.5 |
| Amount of collaboration with crew members | 4 | 34 | 35.5 |
| Experience using the SVS | 2 | 39 | 40 |
| Amount of trust in crew members | 1 | 42 | 45 |
| Experience and ability of the pilot | 0 | 49 | 63 |
| Experience with terrain surrounding destination airport | 0 | 49 | 63 |
| Pilot experience with this specific approach | 0 | 49 | 63 |
| Pilot experience with this specific landing | 0 | 49 | 63 |
| Pilot preference | 0 | 49 | 63 |
| Proximity to the destination airport | 0 | 49 | 63 |
| Machine | | | |
| Intuitiveness/usability of the SVS | 31 | 10 | 11 |
| Degree of display clutter | 11 | 19 | 19.5 |
| Degree of overlay with PFD data | 11 | 19 | 19.5 |
| Auditory vs. visual warning | 9 | 21 | 23.5 |
| Display size | 9 | 21 | 23.5 |
| Color of symbols/text | 6 | 29 | 30 |
| Color of terrain | 6 | 29 | 30 |
| FOV currently depicted on the SVS display | 6 | 29 | 30 |
| Pictorial scene information density | 5 | 32 | 32.5 |
| Feedback delay | 4 | 34 | 35.5 |
| Layout of controls | 4 | 34 | 35.5 |
| Location of the SVS display in the cockpit | 4 | 34 | 35.5 |
| Size of symbols/text | 3 | 38 | 38 |
| Number of key presses required to access desired informati | 2 | 39 | 40 |
| Placement of controls | 2 | 39 | 40 |
| Number of layers in menu structure | 1 | 42 | 45 |
| Number of obstacles currently in view | 1 | 42 | 45 |
| Processing time (to display data from terrain database) | 1 | 42 | 45 |
| Tactile feedback from controls | 1 | 42 | 45 |
| Ability to declutter SVS display | 0 | 49 | 63 |
| Accuracy of GPS | 0 | 49 | 63 |
| Accuracy of terrain database | 0 | 49 | 63 |
| Functioning/malfunctioning of hardware/software | 0 | 49 | 63 |
| Glare on SVS | 0 | 49 | 63 |
| Limitations of the machines processor | 0 | 49 | 63 |
| Number of highlighted features currently in view | 0 | 49 | 63 |
| Physical condition of display surfaces | 0 | 49 | 63 |
| Update rate of GPS | 0 | 49 | 63 |
| Update rate of terrain database | 0 | 49 | 63 |

| INFLUENCE TOTALS | SCORE | RANK |
|---|---|---|
| Ability to declutter SVS display | 5 | 62 |
| Accuracy of GPS | 20 | 4 |
| Accuracy of information from displays other than the SVS | 15 | 14 |
| Accuracy of pilots mental model of the environment | 6 | 56 |
| Accuracy of pilots mental model of the SVS | 8 | 46 |
| Accuracy of terrain database | 20 | 4 |
| Altitude of the aircraft (too low/high?) | 4 | 67 |
| Amount of collaboration with crew members | 5 | 62 |
| Amount of display cross-checking | 15 | 14 |
| Amount of information available from displays other SVS | 12 | 30 |
| Amount of noise in cockpit | 4 | 67 |
| Amount of time spent looking out-the-window | 15 | 14 |
| Amount of time spent reading instruments other than the SVS | 9 | 38 |
| Amount of time spent viewing the SVS display | 15 | 14 |
| Amount of trust in crew members | 3 | 73 |
| Amount of trust in SVS | 7 | 51 |
| Amount of trust in systems other than the SVS | 4 | 67 |
| ATC workload | 0 | 77 |
| Auditory vs. visual warning | 13 | 26 |
| Ceiling visibility at destination airport | 14 | 20 |
| Color of symbols/text | 14 | 20 |
| Color of terrain | 12 | 30 |
| Current level of SA | 8 | 46 |
| Degree of display clutter | 14 | 20 |
| Degree of overlay with PFD data | 15 | 14 |
| Degree of pilot fatigue | 8 | 46 |
| Degree of redundant coding of SVS data | 14 | 20 |
| Degree of time pressure (is aircraft arriving on time, early) | 13 | 26 |
| Difficulty of approach | 20 | 4 |
| Difficulty of landing | 19 | 7 |
| Difficulty of terrain environment at destination airport | 24 | 2 |
| Display size | 14 | 20 |
| Experience and ability of the pilot | 22 | 3 |
| Experience using the SVS | 16 | 12 |
| Experience with terrain surrounding destination airport | 11 | 32 |
| Feedback delay | 10 | 36 |
| FOV currently depicted on the SVS display | 5 | 62 |
| Functioning/malfunctioning of displays other than the SVS | 17 | 8 |
| Functioning/malfunctioning of hardware/software | 13 | 26 |
| Glare on displays other than the SVS | 7 | 51 |

| | | |
|---|---|---|
| Glare on SVS | 16 | 12 |
| Inference delay | 1 | 75 |
| Inference error | 6 | 56 |
| Intuitiveness/usability of the SVS | 30 | 1 |
| Layout of controls | 7 | 51 |
| Level of mental workload | 15 | 14 |
| Level of self confidence | 5 | 62 |
| Lighting conditions in the cockpit | 1 | 75 |
| Limitations of the machines processor | 17 | 8 |
| Location of the SVS display in the cockpit | 9 | 38 |
| Number of errors in perceiving SVS data | 6 | 56 |
| Number of highlighted features currently in view | 9 | 38 |
| Number of key presses required to access desired information | 6 | 56 |
| Number of layers in menu structure | 11 | 32 |
| Number of obstacles currently in view | 9 | 38 |
| Physical condition of display surfaces | 13 | 26 |
| Physical state of the aircraft | 8 | 46 |
| Physical state of the engines | 8 | 46 |
| Pictorial scene information density | 17 | 8 |
| Pilot error when using the SVS | 6 | 56 |
| Pilot experience with this specific approach | 11 | 32 |
| Pilot experience with this specific landing | 11 | 32 |
| Pilot preference | 17 | 8 |
| Pilots level of confidence in his/her perception of the SVS | 4 | 67 |
| Pilots level of confidence in his/her perception of the world | 4 | 67 |
| Pilots level of confidence in the accuracy of the SVS | 7 | 51 |
| Placement of controls | 9 | 38 |
| Processing time (to display data from terrain database) | 10 | 36 |
| Proximity to the destination airport | 6 | 56 |
| Size of symbols/text | 9 | 38 |
| Speed of aircraft (too low/high?) | 4 | 67 |
| Tactile feedback from controls | 3 | 73 |
| Traffic situation at destination airport | 5 | 62 |
| Update rate of GPS | 9 | 38 |
| Update rate of terrain database | 9 | 38 |
| Usability/intuitiveness of displays other than the SVS | 7 | 51 |
| Weather conditions at destination airport | 14 | 20 |

| SENSITIVITY TOTALS | SCORE | RANK |
|---|---|---|
| Ability to declutter SVS display | 0 | 49 |
| Accuracy of GPS | 0 | 49 |

| | | |
|---|---|---|
| Accuracy of information from displays other than the SVS | 0 | 49 |
| Accuracy of pilots mental model of the environment | 44 | 7 |
| Accuracy of pilots mental model of the SVS | 31 | 10 |
| Accuracy of terrain database | 0 | 49 |
| Altitude of the aircraft (too low/high?) | 9 | 21 |
| Amount of collaboration with crew members | 4 | 34 |
| Amount of display cross-checking | 28 | 13 |
| Amount of information available from displays other SVS | 0 | 49 |
| Amount of noise in cockpit | 0 | 49 |
| Amount of time spent looking out-the-window | 43 | 8 |
| Amount of time spent reading instruments other than the SVS | 52 | 4 |
| Amount of time spent viewing the SVS display | 51 | 5 |
| Amount of trust in crew members | 1 | 42 |
| Amount of trust in SVS | 8 | 27 |
| Amount of trust in systems other than the SVS | 5 | 32 |
| ATC workload | 14 | 17 |
| Auditory vs. visual warning | 9 | 21 |
| Ceiling visibility at destination airport | 0 | 49 |
| Color of symbols/text | 6 | 29 |
| Color of terrain | 6 | 29 |
| Current level of SA | 46 | 6 |
| Degree of display clutter | 11 | 19 |
| Degree of overlay with PFD data | 11 | 19 |
| Degree of pilot fatigue | 8 | 27 |
| Degree of redundant coding of SVS data | 0 | 49 |
| Degree of time pressure (is aircraft arriving on time, early) | 1 | 42 |
| Difficulty of approach | 61 | 3 |
| Difficulty of landing | 62 | 2 |
| Difficulty of terrain environment at destination airport | 0 | 49 |
| Display size | 9 | 21 |
| Experience and ability of the pilot | 0 | 49 |
| Experience using the SVS | 2 | 39 |
| Experience with terrain surrounding destination airport | 0 | 49 |
| Feedback delay | 4 | 34 |
| FOV currently depicted on the SVS display | 6 | 29 |
| Functioning/malfunctioning of displays other than the SVS | 0 | 49 |
| Functioning/malfunctioning of hardware/software | 0 | 49 |
| Glare on displays other than the SVS | 1 | 42 |
| Glare on SVS | 0 | 49 |
| Inference delay | 9 | 21 |
| Inference error | 9 | 21 |
| Intuitiveness/usability of the SVS | 31 | 10 |

| | | |
|---|---|---|
| Layout of controls | 4 | 34 |
| Level of mental workload | 63 | 1 |
| Level of self confidence | 18 | 15 |
| Lighting conditions in the cockpit | 0 | 49 |
| Limitations of the machines processor | 0 | 49 |
| Location of the SVS display in the cockpit | 4 | 34 |
| Number of errors in perceiving SVS data | 32 | 9 |
| Number of highlighted features currently in view | 0 | 49 |
| Number of key presses required to access desired information | 2 | 39 |
| Number of layers in menu structure | 1 | 42 |
| Number of obstacles currently in view | 1 | 42 |
| Physical condition of display surfaces | 0 | 49 |
| Physical state of the aircraft | 0 | 49 |
| Physical state of the engines | 0 | 49 |
| Pictorial scene information density | 5 | 32 |
| Pilot error when using the SVS | 31 | 10 |
| Pilot experience with this specific approach | 0 | 49 |
| Pilot experience with this specific landing | 0 | 49 |
| Pilot preference | 0 | 49 |
| Pilots level of confidence in his/her perception of the SVS | 14 | 17 |
| Pilots level of confidence in his/her perception of the world | 21 | 14 |
| Pilots level of confidence in the accuracy of the SVS | 15 | 16 |
| Placement of controls | 2 | 39 |
| Processing time (to display data from terrain database) | 1 | 42 |
| Proximity to the destination airport | 0 | 49 |
| Size of symbols/text | 3 | 38 |
| Speed of aircraft (too low/high?) | 9 | 21 |
| Tactile feedback from controls | 1 | 42 |
| Traffic situation at destination airport | 0 | 49 |
| Update rate of GPS | 0 | 49 |
| Update rate of terrain database | 0 | 49 |
| Usability/intuitiveness of displays other than the SVS | 0 | 49 |
| Weather conditions at destination airport | 0 | 49 |

| TOP FIFTEEN CHARACTERISTICS (INFLUENCE) | SCORE | RANK |
|---|---|---|
| Intuitiveness/usability of the SVS | 30 | 1 |
| Difficulty of terrain environment at destination airport | 24 | 2 |
| Experience and ability of the pilot | 22 | 3 |
| Difficulty of approach | 20 | 4 |
| Accuracy of GPS | 20 | 4 |

| | | |
|---|---|---|
| Accuracy of terrain database | 20 | 4 |
| Difficulty of landing | 19 | 7 |
| Functioning/malfunctioning of displays other than the SVS | 17 | 8 |
| Pilot preference | 17 | 8 |
| Limitations of the machines processor | 17 | 8 |
| Pictorial scene information density | 17 | 8 |
| Experience using the SVS | 16 | 12 |
| Glare on SVS | 16 | 12 |
| Accuracy of information from displays other than the SVS | 15 | 14 |
| Amount of display cross-checking | 15 | 14 |

| TOP FIFTEEN CHARACTERISTICS (SENSITIVITY) | SCORE | RANK |
|---|---|---|
| Level of mental workload | 63 | 1 |
| Difficulty of landing | 62 | 2 |
| Difficulty of approach | 61 | 3 |
| Amount of time spent reading instruments other than the SVS | 52 | 4 |
| Amount of time spent viewing the SVS display | 51 | 5 |
| Current level of SA | 46 | 6 |
| Accuracy of pilots mental model of the environment | 44 | 7 |
| Amount of time spent looking out-the-window | 43 | 8 |
| Number of errors in perceiving SVS data | 32 | 9 |
| Accuracy of pilots mental model of the SVS | 31 | 10 |
| Pilot error when using the SVS | 31 | 10 |
| Intuitiveness/usability of the SVS | 31 | 10 |
| Amount of display cross-checking | 28 | 13 |
| Pilots level of confidence in his/her perception of the world | 21 | 14 |
| Level of self confidence | 18 | 15 |

| RANK (2) |
| ---: |
| 65 |
| 5 |
| 15.8 |
| 59.5 |
| 49 |
| 5 |
| 70.5 |
| 65 |
| 15.8 |
| 31.5 |
| 70.5 |
| 15.8 |
| 42.5 |
| 15.8 |
| 74.5 |
| 54 |
| 70.5 |
| 77 |
| 28.5 |
| 23.5 |
| 23.5 |
| 31.5 |
| 49 |
| 23.5 |
| 15.8 |
| 49 |
| 23.5 |
| 28.5 |
| 5 |
| 8 |
| 2 |
| 23.5 |
| 3 |
| 13.5 |
| 34.5 |
| 37.5 |
| 65 |
| 10.5 |
| 28.5 |
| 54 |

| |
|---|
| 13.5 |
| 76.5 |
| 59.5 |
| 1 |
| 54 |
| 15.8 |
| 65 |
| 76.5 |
| 10.5 |
| 42.5 |
| 59.5 |
| 42.5 |
| 59.5 |
| 34.5 |
| 42.5 |
| 28.5 |
| 49 |
| 49 |
| 10.5 |
| 59.5 |
| 34.5 |
| 34.5 |
| 10.5 |
| 70.5 |
| 70.5 |
| 54 |
| 42.5 |
| 37.5 |
| 59.5 |
| 42.5 |
| 70.5 |
| 74.5 |
| 65 |
| 42.5 |
| 42.5 |
| 54 |
| 23.5 |

| RANK (2) |
|---|
| 64 |
| 64 |

| |
|---|
| 64 |
| 7 |
| 11 |
| 64 |
| 24.5 |
| 36.5 |
| 14 |
| 64 |
| 64 |
| 8 |
| 4 |
| 5 |
| 46 |
| 28.5 |
| 33.5 |
| 18.5 |
| 24.5 |
| 64 |
| 31 |
| 31 |
| 6 |
| 20.5 |
| 20.5 |
| 28.5 |
| 64 |
| 46 |
| 3 |
| 2 |
| 64 |
| 24.5 |
| 64 |
| 41 |
| 64 |
| 36.5 |
| 31 |
| 64 |
| 64 |
| 46 |
| 64 |
| 24.5 |
| 24.5 |
| 11 |

| |
|---|
| 36.5 |
| 1 |
| 16 |
| 64 |
| 64 |
| 36.5 |
| 9 |
| 64 |
| 41 |
| 46 |
| 46 |
| 64 |
| 64 |
| 64 |
| 33.5 |
| 11 |
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| 64 |
| 64 |
| 18.5 |
| 15 |
| 17 |
| 41 |
| 46 |
| 64 |
| 39 |
| 24.5 |
| 46 |
| 64 |
| 64 |
| 64 |
| 64 |
| 64 |

| RANK (2) |
|---|
| 1 |
| 2 |
| 3 |
| 5 |
| 5 |

| |
|---|
| 5 |
| 8 |
| 10.5 |
| 10.5 |
| 10.5 |
| 10.5 |
| 13.5 |
| 13.5 |
| 15.8 |
| 15.8 |

| RANK (2) |
|---|
| 1 |
| 2 |
| 3 |
| 4 |
| 5 |
| 6 |
| 7 |
| 8 |
| 9 |
| 11 |
| 11 |
| 11 |
| 14 |
| 15 |
| 16 |

**SVS MATRIX**

| | Drivers \ Receivers | Accuracy of information from displays other than the SVS | Altitude of the aircraft (too low/high?) | Amount of information available from displays other than SVS | Amount of noise in the cockpit | ATC workload | Ceiling visibility at destination airport | Degree of redundant coding of SVS data | Degree of time pressure | Difficulty of approach | Difficulty of landing | Difficulty of terrain enviro | Functioning/mal | Glare |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Environment** | Accuracy of information from displays other than the SVS | | 1 | | | | | | 1 | 1 | 1 | | | |
| | Altitude of the aircraft (too low/high?) | | | | | 1 | | | | 1 | 1 | | | |
| | Amount of information available from displays other than SVS | | | | | | | | | 1 | 1 | | | |
| | Amount of noise in cockpit | | | | | | | | | | | | | |
| | ATC workload | | | | | | | | | | | | | |
| | Ceiling visibility at destination airport | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Degree of redundant coding of SVS data | | | | | | | | | | | | | |
| | Degree of time pressure | | | | | 1 | | | | 1 | 1 | | | |
| | Difficulty of approach | | | | | 1 | | | | | 1 | | | |
| | Difficulty of landing | | | | | 1 | | | | | | | | |
| | Difficulty of terrain environment at destination airport | | 1 | | | | | | | 1 | 1 | | | |
| | Functioning/malfunctioning of displays other than the SVS | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Glare on displays other than the SVS | | | | | | | | | 1 | 1 | | | |
| | Lighting conditions in the cockpit | | | | | | | | | | | | | 1 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Physical state of the aircraft | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Physical state of the engines | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Speed of aircraft (too low/high?) | | | | | 1 | | | | 1 | 1 | | | |
| | Traffic situation at destination airport | | | | | 1 | | | | 1 | 1 | | | |
| | Usability/intuitiveness of displays other than the SVS | | | | | | | | | 1 | 1 | | | |
| | Weather conditions at destination airport | | 1 | | | 1 | | | | 1 | 1 | | | |
| **Pilot** | Accuracy of pilots mental model of the environment | | | | | | | | | 1 | 1 | | | |
| | Accuracy of pilots mental model of the SVS | | | | | | | | | 1 | 1 | | | |
| | Amount of collaboration with crew members | | | | | | | | | 1 | 1 | | | |
| | Amount of display cross-checking | | | | | | | | | 1 | 1 | | | |
| | Amount of time spent looking out-the-window | | | | | | | | | 1 | 1 | | | |
| | Amount of time spent reading instruments other than the SVS | | | | | | | | | 1 | 1 | | | |
| | Amount of time spent viewing the SVS display | | | | | | | | | 1 | 1 | | | |
| | Amount of trust in crew members | | | | | | | | | 1 | 1 | | | |
| | Amount of trust in SVS | | | | | | | | | | | | | |
| | Amount of trust in systems other than the SVS | | | | | | | | | | | | | |
| | Current level of SA | | | | | | | | | 1 | 1 | | | |
| | Degree of pilot fatigue | | | | | | | | | 1 | 1 | | | |
| | Experience and ability of the pilot | | | | | 1 | | | | 1 | 1 | | | |
| | Experience using the SVS | | | | | | | | | 1 | 1 | | | |
| | Experience with terrain surrounding destination airport | | | | | | | | | 1 | 1 | | | |
| | Inference delay | | | | | | | | | | | | | |
| | Inference error | | | | | | | | | 1 | 1 | | | |
| | Level of mental workload | | | | | | | | | 1 | 1 | | | |
| | Level of self confidence | | | | | | | | | | | | | |
| | Number of errors in perceiving SVS data | | | | | | | | | 1 | 1 | | | |
| | Pilot error when using the SVS | | | | | | | | | 1 | 1 | | | |
| | Pilot experience with this specific approach | | | | | | | | | 1 | 1 | | | |
| | Pilot experience with this specific landing | | | | | | | | | 1 | 1 | | | |
| | Pilot preference | | | | | | | | | | | | | |
| | Pilots level of confidence in his/her perception of the SVS | | | | | | | | | | | | | |
| | Pilots level of confidence in his/her perception of the world | | | | | | | | | | | | | |
| | Pilots level of confidence in the accuracy of the SVS | | | | | | | | | | | | | |
| | Proximity to the destination airport | | | | | | | | | | | | | |
| **Machine** | Ability to declutter SVS display | | | | | | | | | 1 | 1 | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Accuracy of GPS | | 1 | | | 1 | | | | 1 | 1 | | | |
| Accuracy of terrain database | | 1 | | | 1 | | | | 1 | 1 | | | |
| Auditory vs. visual warning | | | | | | | | | 1 | 1 | | | |
| Color of symbols/text | | | | | | | | | 1 | 1 | | | |
| Color of terrain | | | | | | | | | 1 | 1 | | | |
| Degree of display clutter | | | | | | | | | 1 | 1 | | | |
| Degree of overlay with PFD data | | | | | | | | | 1 | 1 | | | |
| Display size | | | | | | | | | 1 | 1 | | | |
| Feedback delay | | | | | | | | | 1 | 1 | | | |
| FOV currently depicted on the SVS display | | | | | | | | | 1 | 1 | | | |
| Functioning/malfunctioning of hardware/software | | | | | | | | | 1 | 1 | | | |
| Glare on SVS | | | | | | | | | 1 | 1 | | | |
| Intuitiveness/usability of the SVS | | | | | | | | | 1 | 1 | | | |
| Layout of controls | | | | | | | | | 1 | 1 | | | |
| Limitations of the machines processor | | | | | | | | | 1 | 1 | | | |
| Location of the SVS display in the cockpit | | | | | | | | | 1 | 1 | | | |
| Number of highlighted features currently in view | | | | | | | | | 1 | 1 | | | |
| Number of key presses required to access desired information | | | | | | | | | 1 | 1 | | | |
| Number of layers in menu structure | | | | | | | | | 1 | 1 | | | |
| Number of obstacles currently in view | | | | | | | | | 1 | 1 | | | |
| Physical condition of display surfaces | | | | | | | | | 1 | 1 | | | |
| Pictorial scene information density | | | | | | | | | 1 | 1 | | | |
| Placement of controls | | | | | | | | | 1 | 1 | | | |
| Processing time (to display data from terrain database) | | | | | | | | | 1 | 1 | | | |
| Size of symbols/text | | | | | | | | | 1 | 1 | | | |
| Tactile feedback from controls | | | | | | | | | | | | | |
| Update rate of GPS | | | | | | | | | 1 | 1 | | | |
| Update rate of terrain database | | | | | | | | | 1 | 1 | | | |
| **SENSITIVITY TOTAL** | 0 | 9 | 0 | 0 | 14 | 0 | 0 | 1 | 61 | 62 | 0 | 0 | 1 |
| **SENSITIVITY RANK (2)** | 63 | 23.5 | 63 | 63 | 17.5 | 63 | 63 | 45 | 3 | 2 | 63 | 63 | 45 |

…onment at destination airport

…alfunctioning of displays other than the SVS

…e on displays other than the SVS

| Environment | | | | | | | Pilot | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lighting conditions in the cockpit | Physical state of the aircraft | Physical state of the engines | Speed of the aircraft | Traffic situation at destination airport | Usability/intuitiveness of displays other than the SVS | Weather conditions at destination airport | Accuracy of pilots mental model of the environment | Accuracy of pilots mental model fo the SVS | Amount of collaboration with crew members | Amount of display cross-checking | Amount of time spent looking out-the-window | Amount of time spent reading instruments other than SVS | Amount of time spent viewing the SVS display | Amount of trust in crew members | Amount of trust in SVS | Amount of trust in systems other than the SVS | Current level of SA | Degree of pilot fatigue | Experience and ability of the pilot | Experience using the SVS | Experience with terrain surrounding destination airport | Inference delay | Inference error | Level of mental workload | Level of self confidence | Number of errors in percei… | Pilot error when… | Pilot … |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 1 | | | | 1 | | | 1 | 1 | 1 | | | | 1 | 1 | | | | | | | 1 | 1 | | | |
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...eiving SVS data

...n using the SVS

...t experience with this specific approach

**Machine**

| Pilot expericence with this specific landing | Pilot preference | Pilots level of confidence in his/her perception of the SVS | Pilots level of confidence in his/her perception of the world | Pilots level of confidence in the accuracy of the SVS | Proximity to destination airport | Ability to declutter SVS display | Accuracy of GPS | Accuracy of terrain database | Auditory vs. visual warning | Color of symbols/text | Color of terrain | Degree of display clutter | Degree of overlay with PFD data | Display size | Feedback delay | FOV currently depicted on the SVS display | Functioning/malfunctioning of hardware/software | Glare on SVS | Intuitiveness/usability of the SVS | Layout of controls | Limiations of the machines processor | Location of the SVS display | Number of highlighted features currently in view | Number of key presses required to access desired | Number of layers in menu structure | Number of obstacles curren | Physical conditi | Pictori |
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| 0 | 0 | 14 | 21 | 15 | 0 | 0 | 0 | 0 | 9 | 6 | 6 | 11 | 11 | 9 | 4 | 6 | 0 | 0 | 31 | 4 | 0 | 4 | 0 | 2 | 1 | 1 | 0 | 5 |
| 63 | 63 | 17.5 | 14 | 16 | 63 | 63 | 63 | 63 | 23.5 | 30 | 30 | 19.5 | 19.5 | 23.5 | 35.5 | 30 | 63 | 63 | 11 | 35.5 | 63 | 35.5 | 63 | 40 | 45 | 45 | 63 | 32.5 |

...ed information

...ently in view

...ation of display surfaces

...torial scene information density

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Placement of controls | | | | | | | | | | | | | | | |
| Processing time (to display data from terrain database) | | | | | | | | | | | | | | | |
| Size of symbols/text | | | | | | | | | | | | | | | |
| Tactile feedback from controls | | | | | | | | | | | | | | | |
| Update rate of GPS | | | | | | | | | | | | | | | |
| Update rate of terrain database | | | | | | | | | | | | | | | |
| **INFLUENCE TOTAL** | | 15 | 4 | 12 | 4 | 0 | 14 | 14 | 13 | 20 | 19 | 24 | 17 | 7 | 1 |
| **INFLUENCE (2)** | | 16.5 | 69.5 | 30.5 | 69.5 | 77 | 22.5 | 22.5 | 27.5 | 5 | 7 | 2 | 9.5 | 53 | 75.5 |

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| | | | | | | 5 | 64 |
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| | | | | | | 15 | 16.5 |
| | | | | | | 9 | 41.5 |
| | | | | | | 15 | 16.5 |
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| | | | | | | 9 | 41.5 |
| 2 | 1 | 3 | 1 | 0 | 0 | | |
| 40 | 45 | 38 | 45 | 63 | 63 | | |

| | INFLUENCE TOTALS | SCORE | RANK | RANK (2) |
|---|---|---|---|---|
| m | Intuitiveness/usability of the SVS | 30 | 1 | 1 |
| w | Difficulty of terrain environment at destination airport | 24 | 2 | 2 |
| p | Experience and ability of the pilot | 22 | 3 | 3 |
| w | Difficulty of approach | 20 | 4 | 5 |
| m | Accuracy of GPS | 20 | 4 | 5 |
| m | Accuracy of terrain database | 20 | 4 | 5 |
| w | Difficulty of landing | 19 | 7 | 7 |
| w | Functioning/malfunctioning of displays other than the SVS | 17 | 8 | 9.5 |
| p | Pilot preference | 17 | 8 | 9.5 |
| m | Limitations of the machines processor | 17 | 8 | 9.5 |
| m | Pictorial scene information density | 17 | 8 | 9.5 |
| p | Experience using the SVS | 16 | 12 | 12.5 |
| m | Glare on SVS | 16 | 12 | 12.5 |
| w | Accuracy of information from displays other than the SVS | 15 | 14 | 16.5 |
| p | Amount of display cross-checking | 15 | 14 | 16.5 |
| p | Amount of time spent looking out-the-window | 15 | 14 | 16.5 |
| p | Amount of time spent viewing the SVS display | 15 | 14 | 16.5 |
| p | Level of mental workload | 15 | 14 | 16.5 |
| m | Degree of overlay with PFD data | 15 | 14 | 16.5 |
| w | Ceiling visibility at destination airport | 14 | 20 | 22.5 |
| w | Degree of redundant coding of SVS data | 14 | 20 | 22.5 |
| w | Weather conditions at destination airport | 14 | 20 | 22.5 |
| m | Color of symbols/text | 14 | 20 | 22.5 |
| m | Degree of display clutter | 14 | 20 | 22.5 |
| m | Display size | 14 | 20 | 22.5 |
| w | Degree of time pressure (is aircraft arriving on time, early) | 13 | 26 | 27.5 |
| m | Auditory vs. visual warning | 13 | 26 | 27.5 |
| m | Functioning/malfunctioning of hardware/software | 13 | 26 | 27.5 |
| m | Physical condition of display surfaces | 13 | 26 | 27.5 |
| w | Amount of information available from displays other SVS | 12 | 30 | 30.5 |
| m | Color of terrain | 12 | 30 | 30.5 |
| p | Experience with terrain surrounding destination airport | 11 | 32 | 33.5 |
| p | Pilot experience with this specific approach | 11 | 32 | 33.5 |
| p | Pilot experience with this specific landing | 11 | 32 | 33.5 |
| m | Number of layers in menu structure | 11 | 32 | 33.5 |
| m | Feedback delay | 10 | 36 | 36.5 |
| m | Processing time (to display data from terrain database) | 10 | 36 | 36.5 |
| p | Amount of time spent reading instruments other than the SVS | 9 | 38 | 41.5 |
| m | Location of the SVS display in the cockpit | 9 | 38 | 41.5 |
| m | Number of highlighted features currently in view | 9 | 38 | 41.5 |

| | | | | |
|---|---|---|---|---|
| m | Number of obstacles currently in view | 9 | 38 | 41.5 |
| m | Placement of controls | 9 | 38 | 41.5 |
| m | Size of symbols/text | 9 | 38 | 41.5 |
| m | Update rate of GPS | 9 | 38 | 41.5 |
| m | Update rate of terrain database | 9 | 38 | 41.5 |
| w | Physical state of the aircraft | 8 | 46 | 48 |
| w | Physical state of the engines | 8 | 46 | 48 |
| p | Accuracy of pilots mental model of the SVS | 8 | 46 | 48 |
| p | Current level of SA | 8 | 46 | 48 |
| p | Degree of pilot fatigue | 8 | 46 | 48 |
| w | Glare on displays other than the SVS | 7 | 51 | 53 |
| w | Usability/intuitiveness of displays other than the SVS | 7 | 51 | 53 |
| p | Amount of trust in SVS | 7 | 51 | 53 |
| p | Pilots level of confidence in the accuracy of the SVS | 7 | 51 | 53 |
| m | Layout of controls | 7 | 51 | 53 |
| p | Accuracy of pilots mental model of the environment | 6 | 56 | 58.5 |
| p | Inference error | 6 | 56 | 58.5 |
| p | Number of errors in perceiving SVS data | 6 | 56 | 58.5 |
| p | Pilot error when using the SVS | 6 | 56 | 58.5 |
| p | Proximity to the destination airport | 6 | 56 | 58.5 |
| m | Number of key presses required to access desired information | 6 | 56 | 58.5 |
| w | Traffic situation at destination airport | 5 | 62 | 64 |
| p | Amount of collaboration with crew members | 5 | 62 | 64 |
| p | Level of self confidence | 5 | 62 | 64 |
| m | Ability to declutter SVS display | 5 | 62 | 64 |
| m | FOV currently depicted on the SVS display | 5 | 62 | 64 |
| w | Altitude of the aircraft (too low/high?) | 4 | 67 | 69.5 |
| w | Amount of noise in cockpit | 4 | 67 | 69.5 |
| w | Speed of aircraft (too low/high?) | 4 | 67 | 69.5 |
| p | Amount of trust in systems other than the SVS | 4 | 67 | 69.5 |
| p | Pilots level of confidence in his/her perception of the SVS | 4 | 67 | 69.5 |
| p | Pilots level of confidence in his/her perception of the world | 4 | 67 | 69.5 |
| p | Amount of trust in crew members | 3 | 73 | 73.5 |
| m | Tactile feedback from controls | 3 | 73 | 73.5 |
| w | Lighting conditions in the cockpit | 1 | 75 | 75.5 |
| p | Inference delay | 1 | 75 | 75.5 |
| w | ATC workload | 0 | 77 | 77 |

| | SENSITIVITY TOTALS | SCORE | RANK | RANK (2) |
|---|---|---|---|---|
| m | Level of mental workload | 63 | 1 | 1 |
| m | Difficulty of landing | 62 | 2 | 2 |
| m | Difficulty of approach | 61 | 3 | 3 |
| m | Amount of time spent reading instruments other than the SVS | 52 | 4 | 4 |
| m | Amount of time spent viewing the SVS display | 51 | 5 | 5 |
| m | Current level of SA | 46 | 6 | 6 |
| m | Accuracy of pilots mental model of the environment | 44 | 7 | 7 |
| m | Amount of time spent looking out-the-window | 43 | 8 | 8 |
| m | Number of errors in perceiving SVS data | 32 | 9 | 9 |
| m | Intuitiveness/usability of the SVS | 31 | 10 | 11 |
| m | Accuracy of pilots mental model of the SVS | 31 | 10 | 11 |
| m | Pilot error when using the SVS | 31 | 10 | 11 |
| m | Amount of display cross-checking | 28 | 13 | 13 |
| m | Pilots level of confidence in his/her perception of the world | 21 | 14 | 14 |
| m | Level of self confidence | 18 | 15 | 15 |
| m | Pilots level of confidence in the accuracy of the SVS | 15 | 16 | 16 |
| m | Pilots level of confidence in his/her perception of the SVS | 14 | 17 | 17.5 |
| m | ATC workload | 14 | 17 | 17.5 |
| m | Degree of display clutter | 11 | 19 | 19.5 |
| m | Degree of overlay with PFD data | 11 | 19 | 19.5 |
| m | Auditory vs. visual warning | 9 | 21 | 23.5 |
| m | Display size | 9 | 21 | 23.5 |
| m | Inference delay | 9 | 21 | 23.5 |
| m | Inference error | 9 | 21 | 23.5 |
| m | Altitude of the aircraft (too low/high?) | 9 | 21 | 23.5 |
| m | Speed of aircraft (too low/high?) | 9 | 21 | 23.5 |
| m | Amount of trust in SVS | 8 | 27 | 27.5 |
| m | Degree of pilot fatigue | 8 | 27 | 27.5 |
| m | Color of symbols/text | 6 | 29 | 30 |
| p | Color of terrain | 6 | 29 | 30 |
| p | FOV currently depicted on the SVS display | 6 | 29 | 30 |
| p | Pictorial scene information density | 5 | 32 | 32.5 |
| p | Amount of trust in systems other than the SVS | 5 | 32 | 32.5 |
| p | Feedback delay | 4 | 34 | 35.5 |
| p | Layout of controls | 4 | 34 | 35.5 |
| p | Location of the SVS display in the cockpit | 4 | 34 | 35.5 |
| p | Amount of collaboration with crew members | 4 | 34 | 35.5 |
| p | Size of symbols/text | 3 | 38 | 38 |
| p | Number of key presses required to access desired information | 2 | 39 | 40 |
| p | Placement of controls | 2 | 39 | 40 |

| | | | | |
|---|---|---|---|---|
| p | Experience using the SVS | 2 | 39 | 40 |
| p | Number of layers in menu structure | 1 | 42 | 45 |
| p | Number of obstacles currently in view | 1 | 42 | 45 |
| p | Processing time (to display data from terrain database) | 1 | 42 | 45 |
| p | Tactile feedback from controls | 1 | 42 | 45 |
| p | Amount of trust in crew members | 1 | 42 | 45 |
| p | Degree of time pressure (is aircraft arriving on time, early) | 1 | 42 | 45 |
| p | Glare on displays other than the SVS | 1 | 42 | 45 |
| p | Ability to declutter SVS display | 0 | 49 | 63 |
| p | Accuracy of GPS | 0 | 49 | 63 |
| p | Accuracy of terrain database | 0 | 49 | 63 |
| p | Functioning/malfunctioning of hardware/software | 0 | 49 | 63 |
| p | Glare on SVS | 0 | 49 | 63 |
| p | Limitations of the machines processor | 0 | 49 | 63 |
| p | Number of highlighted features currently in view | 0 | 49 | 63 |
| p | Physical condition of display surfaces | 0 | 49 | 63 |
| p | Update rate of GPS | 0 | 49 | 63 |
| w | Update rate of terrain database | 0 | 49 | 63 |
| w | Experience and ability of the pilot | 0 | 49 | 63 |
| w | Experience with terrain surrounding destination airport | 0 | 49 | 63 |
| w | Pilot experience with this specific approach | 0 | 49 | 63 |
| w | Pilot experience with this specific landing | 0 | 49 | 63 |
| w | Pilot preference | 0 | 49 | 63 |
| w | Proximity to the destination airport | 0 | 49 | 63 |
| w | Accuracy of information from displays other than the SVS | 0 | 49 | 63 |
| w | Amount of information available from displays other SVS | 0 | 49 | 63 |
| w | Amount of noise in cockpit | 0 | 49 | 63 |
| w | Ceiling visibility at destination airport | 0 | 49 | 63 |
| w | Degree of redundant coding of SVS data | 0 | 49 | 63 |
| w | Difficulty of terrain environment at destination airport | 0 | 49 | 63 |
| w | Functioning/malfunctioning of displays other than the SVS | 0 | 49 | 63 |
| w | Lighting conditions in the cockpit | 0 | 49 | 63 |
| w | Physical state of the aircraft | 0 | 49 | 63 |
| w | Physical state of the engines | 0 | 49 | 63 |
| w | Traffic situation at destination airport | 0 | 49 | 63 |
| w | Usability/intuitiveness of displays other than the SVS | 0 | 49 | 63 |
| w | Weather conditions at destination airport | 0 | 49 | 63 |

| INFLUENCE TOTALS | SCORE | RANK | RANK (2) |
|---|---|---|---|
| **Environment** | | | |
| Difficulty of terrain environment at destination airport | 24 | 2 | 2 |
| Difficulty of approach | 20 | 4 | 5 |
| Difficulty of landing | 19 | 7 | 7 |
| Functioning/malfunctioning of displays other than the SVS | 17 | 8 | 9.5 |
| Accuracy of information from displays other than the SVS | 15 | 14 | 16.5 |
| Ceiling visibility at destination airport | 14 | 20 | 22.5 |
| Degree of redundant coding of SVS data | 14 | 20 | 22.5 |
| Weather conditions at destination airport | 14 | 20 | 22.5 |
| Degree of time pressure (is aircraft arriving on time, early) | 13 | 26 | 27.5 |
| Amount of information available from displays other SVS | 12 | 30 | 30.5 |
| Physical state of the aircraft | 8 | 46 | 48 |
| Physical state of the engines | 8 | 46 | 48 |
| Glare on displays other than the SVS | 7 | 51 | 53 |
| Usability/intuitiveness of displays other than the SVS | 7 | 51 | 53 |
| Traffic situation at destination airport | 5 | 62 | 64 |
| Altitude of the aircraft (too low/high?) | 4 | 67 | 69.5 |
| Amount of noise in cockpit | 4 | 67 | 69.5 |
| Speed of aircraft (too low/high?) | 4 | 67 | 69.5 |
| Lighting conditions in the cockpit | 1 | 75 | 75.5 |
| ATC workload | 0 | 77 | 77 |
| **Pilot** | | | |
| Experience and ability of the pilot | 22 | 3 | 3 |
| Pilot preference | 17 | 8 | 9.5 |
| Experience using the SVS | 16 | 12 | 12.5 |
| Amount of display cross-checking | 15 | 14 | 16.5 |
| Amount of time spent looking out-the-window | 15 | 14 | 16.5 |
| Amount of time spent viewing the SVS display | 15 | 14 | 16.5 |
| Level of mental workload | 15 | 14 | 16.5 |
| Experience with terrain surrounding destination airport | 11 | 32 | 33.5 |
| Pilot experience with this specific approach | 11 | 32 | 33.5 |
| Pilot experience with this specific landing | 11 | 32 | 33.5 |
| Amount of time spent reading instruments other than the S | 9 | 38 | 41.5 |
| Accuracy of pilots mental model of the SVS | 8 | 46 | 48 |
| Current level of SA | 8 | 46 | 48 |
| Degree of pilot fatigue | 8 | 46 | 48 |
| Amount of trust in SVS | 7 | 51 | 53 |
| Pilots level of confidence in the accuracy of the SVS | 7 | 51 | 53 |
| Accuracy of pilots mental model of the environment | 6 | 56 | 58.5 |

| | | | |
|---|---|---|---|
| Inference error | 6 | 56 | 58.5 |
| Number of errors in perceiving SVS data | 6 | 56 | 58.5 |
| Pilot error when using the SVS | 6 | 56 | 58.5 |
| Proximity to the destination airport | 6 | 56 | 58.5 |
| Amount of collaboration with crew members | 5 | 62 | 64 |
| Level of self confidence | 5 | 62 | 64 |
| Amount of trust in systems other than the SVS | 4 | 67 | 69.5 |
| Pilots level of confidence in his/her perception of the SVS | 4 | 67 | 69.5 |
| Pilots level of confidence in his/her perception of the world | 4 | 67 | 69.5 |
| Amount of trust in crew members | 3 | 73 | 73.5 |
| Inference delay | 1 | 75 | 75.5 |
| Machine | | | |
| Intuitiveness/usability of the SVS | 30 | 1 | 1 |
| Accuracy of GPS | 20 | 4 | 5 |
| Accuracy of terrain database | 20 | 4 | 5 |
| Limitations of the machines processor | 17 | 8 | 9.5 |
| Pictorial scene information density | 17 | 8 | 9.5 |
| Glare on SVS | 16 | 12 | 12.5 |
| Degree of overlay with PFD data | 15 | 14 | 16.5 |
| Color of symbols/text | 14 | 20 | 22.5 |
| Degree of display clutter | 14 | 20 | 22.5 |
| Display size | 14 | 20 | 22.5 |
| Auditory vs. visual warning | 13 | 26 | 27.5 |
| Functioning/malfunctioning of hardware/software | 13 | 26 | 27.8 |
| Physical condition of display surfaces | 13 | 26 | 27.8 |
| Color of terrain | 12 | 30 | 30.5 |
| Number of layers in menu structure | 11 | 32 | 33.5 |
| Feedback delay | 10 | 36 | 36.5 |
| Processing time (to display data from terrain database) | 10 | 36 | 36.5 |
| Location of the SVS display in the cockpit | 9 | 38 | 41.5 |
| Number of highlighted features currently in view | 9 | 38 | 41.5 |
| Number of obstacles currently in view | 9 | 38 | 41.5 |
| Placement of controls | 9 | 38 | 41.5 |
| Size of symbols/text | 9 | 38 | 41.5 |
| Update rate of GPS | 9 | 38 | 41.5 |
| Update rate of terrain database | 9 | 38 | 41.5 |
| Layout of controls | 7 | 51 | 53 |
| Number of key presses required to access desired informati | 6 | 56 | 58.5 |
| Ability to declutter SVS display | 5 | 62 | 64 |
| FOV currently depicted on the SVS display | 5 | 62 | 64 |
| Tactile feedback from controls | 3 | 73 | 73.5 |

| SENSITIVITY TOTALS | SCORE | RANK | RANK (2) |
|---|---|---|---|
| **Environment** | | | |
| Difficulty of approach | 61 | 3 | 3 |
| ATC workload | 14 | 17 | 17.5 |
| Altitude of the aircraft (too low/high?) | 9 | 21 | 23.5 |
| Speed of aircraft (too low/high?) | 9 | 21 | 23.5 |
| Degree of time pressure (is aircraft arriving on time, early) | 1 | 42 | 45 |
| Glare on displays other than the SVS | 1 | 42 | 45 |
| Accuracy of information from displays other than the SVS | 0 | 49 | 63 |
| Amount of information available from displays other SVS | 0 | 49 | 63 |
| Amount of noise in cockpit | 0 | 49 | 63 |
| Ceiling visibility at destination airport | 0 | 49 | 63 |
| Degree of redundant coding of SVS data | 0 | 49 | 63 |
| Difficulty of terrain environment at destination airport | 0 | 49 | 63 |
| Functioning/malfunctioning of displays other than the SVS | 0 | 49 | 63 |
| Lighting conditions in the cockpit | 0 | 49 | 63 |
| Physical state of the aircraft | 0 | 49 | 63 |
| Physical state of the engines | 0 | 49 | 63 |
| Traffic situation at destination airport | 0 | 49 | 63 |
| Usability/intuitiveness of displays other than the SVS | 0 | 49 | 63 |
| Weather conditions at destination airport | 0 | 49 | 63 |
| **Pilot** | | | |
| Level of mental workload | 63 | 1 | 1 |
| Amount of time spent reading instruments other than the S | 52 | 4 | 4 |
| Amount of time spent viewing the SVS display | 51 | 5 | 5 |
| Current level of SA | 46 | 6 | 6 |
| Accuracy of pilots mental model of the environment | 44 | 7 | 7 |
| Amount of time spent looking out-the-window | 43 | 8 | 8 |
| Number of errors in perceiving SVS data | 32 | 9 | 9 |
| Accuracy of pilots mental model of the SVS | 31 | 10 | 11 |
| Pilot error when using the SVS | 31 | 10 | 11 |
| Amount of display cross-checking | 28 | 13 | 13 |
| Pilots level of confidence in his/her perception of the world | 21 | 14 | 14 |
| Level of self confidence | 18 | 15 | 15 |
| Pilots level of confidence in the accuracy of the SVS | 15 | 16 | 16 |
| Pilots level of confidence in his/her perception of the SVS | 14 | 17 | 17.5 |
| Inference delay | 9 | 21 | 23.5 |
| Inference error | 9 | 21 | 23.5 |
| Amount of trust in SVS | 8 | 27 | 27.5 |

| | | | |
|---|---|---|---|
| Degree of pilot fatigue | 8 | 27 | 27.5 |
| Amount of trust in systems other than the SVS | 5 | 32 | 32.5 |
| Amount of collaboration with crew members | 4 | 34 | 35.5 |
| Experience using the SVS | 2 | 39 | 40 |
| Amount of trust in crew members | 1 | 42 | 45 |
| Experience and ability of the pilot | 0 | 49 | 63 |
| Experience with terrain surrounding destination airport | 0 | 49 | 63 |
| Pilot experience with this specific approach | 0 | 49 | 63 |
| Pilot experience with this specific landing | 0 | 49 | 63 |
| Pilot preference | 0 | 49 | 63 |
| Proximity to the destination airport | 0 | 49 | 63 |
| Machine | | | |
| Intuitiveness/usability of the SVS | 31 | 10 | 11 |
| Degree of display clutter | 11 | 19 | 19.5 |
| Degree of overlay with PFD data | 11 | 19 | 19.5 |
| Auditory vs. visual warning | 9 | 21 | 23.5 |
| Display size | 9 | 21 | 23.5 |
| Color of symbols/text | 6 | 29 | 30 |
| Color of terrain | 6 | 29 | 30 |
| FOV currently depicted on the SVS display | 6 | 29 | 30 |
| Pictorial scene information density | 5 | 32 | 32.5 |
| Feedback delay | 4 | 34 | 35.5 |
| Layout of controls | 4 | 34 | 35.5 |
| Location of the SVS display in the cockpit | 4 | 34 | 35.5 |
| Size of symbols/text | 3 | 38 | 38 |
| Number of key presses required to access desired informati | 2 | 39 | 40 |
| Placement of controls | 2 | 39 | 40 |
| Number of layers in menu structure | 1 | 42 | 45 |
| Number of obstacles currently in view | 1 | 42 | 45 |
| Processing time (to display data from terrain database) | 1 | 42 | 45 |
| Tactile feedback from controls | 1 | 42 | 45 |
| Ability to declutter SVS display | 0 | 49 | 63 |
| Accuracy of GPS | 0 | 49 | 63 |
| Accuracy of terrain database | 0 | 49 | 63 |
| Functioning/malfunctioning of hardware/software | 0 | 49 | 63 |
| Glare on SVS | 0 | 49 | 63 |
| Limitations of the machines processor | 0 | 49 | 63 |
| Number of highlighted features currently in view | 0 | 49 | 63 |
| Physical condition of display surfaces | 0 | 49 | 63 |
| Update rate of GPS | 0 | 49 | 63 |
| Update rate of terrain database | 0 | 49 | 63 |

## Appendix D

| INFLUENCE TOTALS | SCORE | RANK |
|---|---|---|
| Intuitiveness/usability of the SVS | 30 | 1 |
| Difficulty of terrain environment at destination airport | 24 | 2 |
| Experience and ability of the pilot | 22 | 3 |
| Difficulty of approach | 20 | 5 |
| Accuracy of GPS | 20 | 5 |
| Accuracy of terrain database | 20 | 5 |
| Difficulty of landing | 19 | 7 |
| Functioning/malfunctioning of displays other than the SVS | 17 | 9.5 |
| Pilot preference | 17 | 9.5 |
| Limitations of the machines processor | 17 | 9.5 |
| Pictorial scene information density | 17 | 9.5 |
| Experience using the SVS | 16 | 12.5 |
| Glare on SVS | 16 | 12.5 |
| Accuracy of information from displays other than the SVS | 15 | 16.5 |
| Amount of display cross-checking | 15 | 16.5 |
| Amount of time spent looking out-the-window | 15 | 16.5 |
| Amount of time spent viewing the SVS display | 15 | 16.5 |
| Level of mental workload | 15 | 16.5 |
| Degree of overlay with PFD data | 15 | 16.5 |
| Ceiling visibility at destination airport | 14 | 22.5 |
| Degree of redundant coding of SVS data | 14 | 22.5 |
| Weather conditions at destination airport | 14 | 22.5 |
| Color of symbols/text | 14 | 22.5 |
| Degree of display clutter | 14 | 22.5 |
| Display size | 14 | 22.5 |
| Degree of time pressure (is aircraft arriving on time, early) | 13 | 27.5 |
| Auditory vs. visual warning | 13 | 27.5 |
| Functioning/malfunctioning of hardware/software | 13 | 27.5 |
| Physical condition of display surfaces | 13 | 27.5 |
| Amount of information available from displays other SVS | 12 | 30.5 |
| Color of terrain | 12 | 30.5 |
| Experience with terrain surrounding destination airport | 11 | 33.5 |
| Pilot experience with this specific approach | 11 | 33.5 |
| Pilot experience with this specific landing | 11 | 33.5 |
| Number of layers in menu structure | 11 | 33.5 |
| Feedback delay | 10 | 36.5 |
| Processing time (to display data from terrain database) | 10 | 36.5 |
| Amount of time spent reading instruments other than the SVS | 9 | 41.5 |
| Location of the SVS display in the cockpit | 9 | 41.5 |
| Number of highlighted features currently in view | 9 | 41.5 |

**Appendix D**

| | | |
|---|---|---|
| Number of obstacles currently in view | 9 | 41.5 |
| Placement of controls | 9 | 41.5 |
| Size of symbols/text | 9 | 41.5 |
| Update rate of GPS | 9 | 41.5 |
| Update rate of terrain database | 9 | 41.5 |
| Physical state of the aircraft | 8 | 48 |
| Physical state of the engines | 8 | 48 |
| Accuracy of pilots mental model of the SVS | 8 | 48 |
| Current level of SA | 8 | 48 |
| Degree of pilot fatigue | 8 | 48 |
| Glare on displays other than the SVS | 7 | 53 |
| Usability/intuitiveness of displays other than the SVS | 7 | 53 |
| Amount of trust in SVS | 7 | 53 |
| Pilots level of confidence in the accuracy of the SVS | 7 | 53 |
| Layout of controls | 7 | 53 |
| Accuracy of pilots mental model of the environment | 6 | 58.5 |
| Inference error | 6 | 58.5 |
| Number of errors in perceiving SVS data | 6 | 58.5 |
| Pilot error when using the SVS | 6 | 58.5 |
| Proximity to the destination airport | 6 | 58.5 |
| Number of key presses required to access desired information | 6 | 58.5 |
| Traffic situation at destination airport | 5 | 64 |
| Amount of collaboration with crew members | 5 | 64 |
| Level of self confidence | 5 | 64 |
| Ability to declutter SVS display | 5 | 64 |
| FOV currently depicted on the SVS display | 5 | 64 |
| Altitude of the aircraft (too low/high?) | 4 | 69.5 |
| Amount of noise in cockpit | 4 | 69.5 |
| Speed of aircraft (too low/high?) | 4 | 69.5 |
| Amount of trust in systems other than the SVS | 4 | 69.5 |
| Pilots level of confidence in his/her perception of the SVS | 4 | 69.5 |
| Pilots level of confidence in his/her perception of the world | 4 | 69.5 |
| Amount of trust in crew members | 3 | 73.5 |
| Tactile feedback from controls | 3 | 73.5 |
| Lighting conditions in the cockpit | 1 | 75.5 |
| Inference delay | 1 | 75.5 |
| ATC workload | 0 | 77 |

## Appendix D

| SENSITIVITY TOTALS | SCORE | RANK |
|---|---|---|
| Level of mental workload | 63 | 1 |
| Difficulty of landing | 62 | 2 |
| Difficulty of approach | 61 | 3 |
| Amount of time spent reading instruments other than the SVS | 52 | 4 |
| Amount of time spent viewing the SVS display | 51 | 5 |
| Current level of SA | 46 | 6 |
| Accuracy of pilots mental model of the environment | 44 | 7 |
| Amount of time spent looking out-the-window | 43 | 8 |
| Number of errors in perceiving SVS data | 32 | 9 |
| Intuitiveness/usability of the SVS | 31 | 11 |
| Accuracy of pilots mental model of the SVS | 31 | 11 |
| Pilot error when using the SVS | 31 | 11 |
| Amount of display cross-checking | 28 | 13 |
| Pilots level of confidence in his/her perception of the world | 21 | 14 |
| Level of self confidence | 18 | 15 |
| Pilots level of confidence in the accuracy of the SVS | 15 | 16 |
| Pilots level of confidence in his/her perception of the SVS | 14 | 17.5 |
| ATC workload | 14 | 17.5 |
| Degree of display clutter | 11 | 19.5 |
| Degree of overlay with PFD data | 11 | 19.5 |
| Auditory vs. visual warning | 9 | 23.5 |
| Display size | 9 | 23.5 |
| Inference delay | 9 | 23.5 |
| Inference error | 9 | 23.5 |
| Altitude of the aircraft (too low/high?) | 9 | 23.5 |
| Speed of aircraft (too low/high?) | 9 | 23.5 |
| Amount of trust in SVS | 8 | 27.5 |
| Degree of pilot fatigue | 8 | 27.5 |
| Color of symbols/text | 6 | 30 |
| Color of terrain | 6 | 30 |
| FOV currently depicted on the SVS display | 6 | 30 |
| Pictorial scene information density | 5 | 32.5 |
| Amount of trust in systems other than the SVS | 5 | 32.5 |
| Feedback delay | 4 | 35.5 |
| Layout of controls | 4 | 35.5 |
| Location of the SVS display in the cockpit | 4 | 35.5 |
| Amount of collaboration with crew members | 4 | 35.5 |
| Size of symbols/text | 3 | 38 |
| Number of key presses required to access desired information | 2 | 40 |
| Placement of controls | 2 | 40 |

**Appendix D**

| | | |
|---|---|---|
| Experience using the SVS | 2 | 40 |
| Number of layers in menu structure | 1 | 45 |
| Number of obstacles currently in view | 1 | 45 |
| Processing time (to display data from terrain database) | 1 | 45 |
| Tactile feedback from controls | 1 | 45 |
| Amount of trust in crew members | 1 | 45 |
| Degree of time pressure (is aircraft arriving on time, early) | 1 | 45 |
| Glare on displays other than the SVS | 1 | 45 |
| Ability to declutter SVS display | 0 | 63 |
| Accuracy of GPS | 0 | 63 |
| Accuracy of terrain database | 0 | 63 |
| Functioning/malfunctioning of hardware/software | 0 | 63 |
| Glare on SVS | 0 | 63 |
| Limitations of the machines processor | 0 | 63 |
| Number of highlighted features currently in view | 0 | 63 |
| Physical condition of display surfaces | 0 | 63 |
| Update rate of GPS | 0 | 63 |
| Update rate of terrain database | 0 | 63 |
| Experience and ability of the pilot | 0 | 63 |
| Experience with terrain surrounding destination airport | 0 | 63 |
| Pilot experience with this specific approach | 0 | 63 |
| Pilot experience with this specific landing | 0 | 63 |
| Pilot preference | 0 | 63 |
| Proximity to the destination airport | 0 | 63 |
| Accuracy of information from displays other than the SVS | 0 | 63 |
| Amount of information available from displays other SVS | 0 | 63 |
| Amount of noise in cockpit | 0 | 63 |
| Ceiling visibility at destination airport | 0 | 63 |
| Degree of redundant coding of SVS data | 0 | 63 |
| Difficulty of terrain environment at destination airport | 0 | 63 |
| Functioning/malfunctioning of displays other than the SVS | 0 | 63 |
| Lighting conditions in the cockpit | 0 | 63 |
| Physical state of the aircraft | 0 | 63 |
| Physical state of the engines | 0 | 63 |
| Traffic situation at destination airport | 0 | 63 |
| Usability/intuitiveness of displays other than the SVS | 0 | 63 |
| Weather conditions at destination airport | 0 | 63 |

| INFLUENCE TOTALS | SCORE | RANK |
|---|---|---|
| Ability to declutter SVS display | 5 | 62 |
| Accuracy of GPS | 20 | 4 |
| Accuracy of information from displays other than the SVS | 15 | 14 |
| Accuracy of pilots mental model of the environment | 6 | 56 |
| Accuracy of pilots mental model of the SVS | 8 | 46 |
| Accuracy of terrain database | 20 | 4 |
| Altitude of the aircraft (too low/high?) | 4 | 67 |
| Amount of collaboration with crew members | 5 | 62 |
| Amount of display cross-checking | 15 | 14 |
| Amount of information available from displays other SVS | 12 | 30 |
| Amount of noise in cockpit | 4 | 67 |
| Amount of time spent looking out-the-window | 15 | 14 |
| Amount of time spent reading instruments other than the SVS | 9 | 38 |
| Amount of time spent viewing the SVS display | 15 | 14 |
| Amount of trust in crew members | 3 | 73 |
| Amount of trust in SVS | 7 | 51 |
| Amount of trust in systems other than the SVS | 4 | 67 |
| ATC workload | 0 | 77 |
| Auditory vs. visual warning | 13 | 26 |
| Ceiling visibility at destination airport | 14 | 20 |
| Color of symbols/text | 14 | 20 |
| Color of terrain | 12 | 30 |
| Current level of SA | 8 | 46 |
| Degree of display clutter | 14 | 20 |
| Degree of overlay with PFD data | 15 | 14 |
| Degree of pilot fatigue | 8 | 46 |
| Degree of redundant coding of SVS data | 14 | 20 |
| Degree of time pressure (is aircraft arriving on time, early) | 13 | 26 |
| Difficulty of approach | 20 | 4 |
| Difficulty of landing | 19 | 7 |
| Difficulty of terrain environment at destination airport | 24 | 2 |
| Display size | 14 | 20 |
| Experience and ability of the pilot | 22 | 3 |
| Experience using the SVS | 16 | 12 |
| Experience with terrain surrounding destination airport | 11 | 32 |
| Feedback delay | 10 | 36 |
| FOV currently depicted on the SVS display | 5 | 62 |
| Functioning/malfunctioning of displays other than the SVS | 17 | 8 |
| Functioning/malfunctioning of hardware/software | 13 | 26 |
| Glare on displays other than the SVS | 7 | 51 |

| | | |
|---|---|---|
| Glare on SVS | 16 | 12 |
| Inference delay | 1 | 75 |
| Inference error | 6 | 56 |
| Intuitiveness/usability of the SVS | 30 | 1 |
| Layout of controls | 7 | 51 |
| Level of mental workload | 15 | 14 |
| Level of self confidence | 5 | 62 |
| Lighting conditions in the cockpit | 1 | 75 |
| Limitations of the machines processor | 17 | 8 |
| Location of the SVS display in the cockpit | 9 | 38 |
| Number of errors in perceiving SVS data | 6 | 56 |
| Number of highlighted features currently in view | 9 | 38 |
| Number of key presses required to access desired information | 6 | 56 |
| Number of layers in menu structure | 11 | 32 |
| Number of obstacles currently in view | 9 | 38 |
| Physical condition of display surfaces | 13 | 26 |
| Physical state of the aircraft | 8 | 46 |
| Physical state of the engines | 8 | 46 |
| Pictorial scene information density | 17 | 8 |
| Pilot error when using the SVS | 6 | 56 |
| Pilot experience with this specific approach | 11 | 32 |
| Pilot experience with this specific landing | 11 | 32 |
| Pilot preference | 17 | 8 |
| Pilots level of confidence in his/her perception of the SVS | 4 | 67 |
| Pilots level of confidence in his/her perception of the world | 4 | 67 |
| Pilots level of confidence in the accuracy of the SVS | 7 | 51 |
| Placement of controls | 9 | 38 |
| Processing time (to display data from terrain database) | 10 | 36 |
| Proximity to the destination airport | 6 | 56 |
| Size of symbols/text | 9 | 38 |
| Speed of aircraft (too low/high?) | 4 | 67 |
| Tactile feedback from controls | 3 | 73 |
| Traffic situation at destination airport | 5 | 62 |
| Update rate of GPS | 9 | 38 |
| Update rate of terrain database | 9 | 38 |
| Usability/intuitiveness of displays other than the SVS | 7 | 51 |
| Weather conditions at destination airport | 14 | 20 |

| SENSITIVITY TOTALS | SCORE | RANK |
|---|---|---|
| Ability to declutter SVS display | 0 | 49 |
| Accuracy of GPS | 0 | 49 |

| | | |
|---|---|---|
| Accuracy of information from displays other than the SVS | 0 | 49 |
| Accuracy of pilots mental model of the environment | 44 | 7 |
| Accuracy of pilots mental model of the SVS | 31 | 10 |
| Accuracy of terrain database | 0 | 49 |
| Altitude of the aircraft (too low/high?) | 9 | 21 |
| Amount of collaboration with crew members | 4 | 34 |
| Amount of display cross-checking | 28 | 13 |
| Amount of information available from displays other SVS | 0 | 49 |
| Amount of noise in cockpit | 0 | 49 |
| Amount of time spent looking out-the-window | 43 | 8 |
| Amount of time spent reading instruments other than the SVS | 52 | 4 |
| Amount of time spent viewing the SVS display | 51 | 5 |
| Amount of trust in crew members | 1 | 42 |
| Amount of trust in SVS | 8 | 27 |
| Amount of trust in systems other than the SVS | 5 | 32 |
| ATC workload | 14 | 17 |
| Auditory vs. visual warning | 9 | 21 |
| Ceiling visibility at destination airport | 0 | 49 |
| Color of symbols/text | 6 | 29 |
| Color of terrain | 6 | 29 |
| Current level of SA | 46 | 6 |
| Degree of display clutter | 11 | 19 |
| Degree of overlay with PFD data | 11 | 19 |
| Degree of pilot fatigue | 8 | 27 |
| Degree of redundant coding of SVS data | 0 | 49 |
| Degree of time pressure (is aircraft arriving on time, early) | 1 | 42 |
| Difficulty of approach | 61 | 3 |
| Difficulty of landing | 62 | 2 |
| Difficulty of terrain environment at destination airport | 0 | 49 |
| Display size | 9 | 21 |
| Experience and ability of the pilot | 0 | 49 |
| Experience using the SVS | 2 | 39 |
| Experience with terrain surrounding destination airport | 0 | 49 |
| Feedback delay | 4 | 34 |
| FOV currently depicted on the SVS display | 6 | 29 |
| Functioning/malfunctioning of displays other than the SVS | 0 | 49 |
| Functioning/malfunctioning of hardware/software | 0 | 49 |
| Glare on displays other than the SVS | 1 | 42 |
| Glare on SVS | 0 | 49 |
| Inference delay | 9 | 21 |
| Inference error | 9 | 21 |
| Intuitiveness/usability of the SVS | 31 | 10 |

| | | |
|---|---|---|
| Layout of controls | 4 | 34 |
| Level of mental workload | 63 | 1 |
| Level of self confidence | 18 | 15 |
| Lighting conditions in the cockpit | 0 | 49 |
| Limitations of the machines processor | 0 | 49 |
| Location of the SVS display in the cockpit | 4 | 34 |
| Number of errors in perceiving SVS data | 32 | 9 |
| Number of highlighted features currently in view | 0 | 49 |
| Number of key presses required to access desired information | 2 | 39 |
| Number of layers in menu structure | 1 | 42 |
| Number of obstacles currently in view | 1 | 42 |
| Physical condition of display surfaces | 0 | 49 |
| Physical state of the aircraft | 0 | 49 |
| Physical state of the engines | 0 | 49 |
| Pictorial scene information density | 5 | 32 |
| Pilot error when using the SVS | 31 | 10 |
| Pilot experience with this specific approach | 0 | 49 |
| Pilot experience with this specific landing | 0 | 49 |
| Pilot preference | 0 | 49 |
| Pilots level of confidence in his/her perception of the SVS | 14 | 17 |
| Pilots level of confidence in his/her perception of the world | 21 | 14 |
| Pilots level of confidence in the accuracy of the SVS | 15 | 16 |
| Placement of controls | 2 | 39 |
| Processing time (to display data from terrain database) | 1 | 42 |
| Proximity to the destination airport | 0 | 49 |
| Size of symbols/text | 3 | 38 |
| Speed of aircraft (too low/high?) | 9 | 21 |
| Tactile feedback from controls | 1 | 42 |
| Traffic situation at destination airport | 0 | 49 |
| Update rate of GPS | 0 | 49 |
| Update rate of terrain database | 0 | 49 |
| Usability/intuitiveness of displays other than the SVS | 0 | 49 |
| Weather conditions at destination airport | 0 | 49 |

| TOP FIFTEEN CHARACTERISTICS (INFLUENCE) | SCORE | RANK |
|---|---|---|
| Intuitiveness/usability of the SVS | 30 | 1 |
| Difficulty of terrain environment at destination airport | 24 | 2 |
| Experience and ability of the pilot | 22 | 3 |
| Difficulty of approach | 20 | 4 |
| Accuracy of GPS | 20 | 4 |

| | | |
|---|---|---|
| Accuracy of terrain database | 20 | 4 |
| Difficulty of landing | 19 | 7 |
| Functioning/malfunctioning of displays other than the SVS | 17 | 8 |
| Pilot preference | 17 | 8 |
| Limitations of the machines processor | 17 | 8 |
| Pictorial scene information density | 17 | 8 |
| Experience using the SVS | 16 | 12 |
| Glare on SVS | 16 | 12 |
| Accuracy of information from displays other than the SVS | 15 | 14 |
| Amount of display cross-checking | 15 | 14 |

| TOP FIFTEEN CHARACTERISTICS (SENSITIVITY) | SCORE | RANK |
|---|---|---|
| Level of mental workload | 63 | 1 |
| Difficulty of landing | 62 | 2 |
| Difficulty of approach | 61 | 3 |
| Amount of time spent reading instruments other than the SVS | 52 | 4 |
| Amount of time spent viewing the SVS display | 51 | 5 |
| Current level of SA | 46 | 6 |
| Accuracy of pilots mental model of the environment | 44 | 7 |
| Amount of time spent looking out-the-window | 43 | 8 |
| Number of errors in perceiving SVS data | 32 | 9 |
| Accuracy of pilots mental model of the SVS | 31 | 10 |
| Pilot error when using the SVS | 31 | 10 |
| Intuitiveness/usability of the SVS | 31 | 10 |
| Amount of display cross-checking | 28 | 13 |
| Pilots level of confidence in his/her perception of the world | 21 | 14 |
| Level of self confidence | 18 | 15 |

| RANK (2) |
| ---: |
| 65 |
| 5 |
| 15.8 |
| 59.5 |
| 49 |
| 5 |
| 70.5 |
| 65 |
| 15.8 |
| 31.5 |
| 70.5 |
| 15.8 |
| 42.5 |
| 15.8 |
| 74.5 |
| 54 |
| 70.5 |
| 77 |
| 28.5 |
| 23.5 |
| 23.5 |
| 31.5 |
| 49 |
| 23.5 |
| 15.8 |
| 49 |
| 23.5 |
| 28.5 |
| 5 |
| 8 |
| 2 |
| 23.5 |
| 3 |
| 13.5 |
| 34.5 |
| 37.5 |
| 65 |
| 10.5 |
| 28.5 |
| 54 |

| |
|---|
| 13.5 |
| 76.5 |
| 59.5 |
| 1 |
| 54 |
| 15.8 |
| 65 |
| 76.5 |
| 10.5 |
| 42.5 |
| 59.5 |
| 42.5 |
| 59.5 |
| 34.5 |
| 42.5 |
| 28.5 |
| 49 |
| 49 |
| 10.5 |
| 59.5 |
| 34.5 |
| 34.5 |
| 10.5 |
| 70.5 |
| 70.5 |
| 54 |
| 42.5 |
| 37.5 |
| 59.5 |
| 42.5 |
| 70.5 |
| 74.5 |
| 65 |
| 42.5 |
| 42.5 |
| 54 |
| 23.5 |

| RANK (2) |
|---|
| 64 |
| 64 |

| |
|---|
| 64 |
| 7 |
| 11 |
| 64 |
| 24.5 |
| 36.5 |
| 14 |
| 64 |
| 64 |
| 8 |
| 4 |
| 5 |
| 46 |
| 28.5 |
| 33.5 |
| 18.5 |
| 24.5 |
| 64 |
| 31 |
| 31 |
| 6 |
| 20.5 |
| 20.5 |
| 28.5 |
| 64 |
| 46 |
| 3 |
| 2 |
| 64 |
| 24.5 |
| 64 |
| 41 |
| 64 |
| 36.5 |
| 31 |
| 64 |
| 64 |
| 46 |
| 64 |
| 24.5 |
| 24.5 |
| 11 |

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|---|
| 36.5 |
| 1 |
| 16 |
| 64 |
| 64 |
| 36.5 |
| 9 |
| 64 |
| 41 |
| 46 |
| 46 |
| 64 |
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| 33.5 |
| 11 |
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| 64 |
| 64 |
| 18.5 |
| 15 |
| 17 |
| 41 |
| 46 |
| 64 |
| 39 |
| 24.5 |
| 46 |
| 64 |
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| 64 |

| RANK (2) |
|---|
| 1 |
| 2 |
| 3 |
| 5 |
| 5 |

| |
|---|
| 5 |
| 8 |
| 10.5 |
| 10.5 |
| 10.5 |
| 10.5 |
| 13.5 |
| 13.5 |
| 15.8 |
| 15.8 |

| RANK (2) |
|---|
| 1 |
| 2 |
| 3 |
| 4 |
| 5 |
| 6 |
| 7 |
| 8 |
| 9 |
| 11 |
| 11 |
| 11 |
| 14 |
| 15 |
| 16 |

**SVS MATRIX**

| | Drivers / **Receivers** | Accuracy of information from displays other than the SVS | Altitude of the aircraft (too low/high?) | Amount of information available from displays other than SVS | Amount of noise in the cockpit | ATC workload | Ceiling visibility at destination airport | Degree of redundant coding of SVS data | Degree of time pressure | Difficulty of approach | Difficulty of landing | Difficulty of terrain enviro | Functioning/mal | Glare |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Environment** | Accuracy of information from displays other than the SVS | | 1 | | | | | | 1 | 1 | 1 | | | |
| | Altitude of the aircraft (too low/high?) | | | | | 1 | | | | 1 | 1 | | | |
| | Amount of information available from displays other than SVS | | | | | | | | | 1 | 1 | | | |
| | Amount of noise in cockpit | | | | | | | | | | | | | |
| | ATC workload | | | | | | | | | | | | | |
| | Ceiling visibility at destination airport | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Degree of redundant coding of SVS data | | | | | | | | | | | | | |
| | Degree of time pressure | | | | | 1 | | | | 1 | 1 | | | |
| | Difficulty of approach | | | | | 1 | | | | | 1 | | | |
| | Difficulty of landing | | | | | 1 | | | | | | | | |
| | Difficulty of terrain environment at destination airport | | 1 | | | | | | | 1 | 1 | | | |
| | Functioning/malfunctioning of displays other than the SVS | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Glare on displays other than the SVS | | | | | | | | | 1 | 1 | | | |
| | Lighting conditions in the cockpit | | | | | | | | | | | | | 1 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Physical state of the aircraft | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Physical state of the engines | | 1 | | | 1 | | | | 1 | 1 | | | |
| | Speed of aircraft (too low/high?) | | | | | 1 | | | | 1 | 1 | | | |
| | Traffic situation at destination airport | | | | | 1 | | | | 1 | 1 | | | |
| | Usability/intuitiveness of displays other than the SVS | | | | | | | | | 1 | 1 | | | |
| | Weather conditions at destination airport | | 1 | | | 1 | | | | 1 | 1 | | | |
| **Pilot** | Accuracy of pilots mental model of the environment | | | | | | | | | 1 | 1 | | | |
| | Accuracy of pilots mental model of the SVS | | | | | | | | | 1 | 1 | | | |
| | Amount of collaboration with crew members | | | | | | | | | 1 | 1 | | | |
| | Amount of display cross-checking | | | | | | | | | 1 | 1 | | | |
| | Amount of time spent looking out-the-window | | | | | | | | | 1 | 1 | | | |
| | Amount of time spent reading instruments other than the SVS | | | | | | | | | 1 | 1 | | | |
| | Amount of time spent viewing the SVS display | | | | | | | | | 1 | 1 | | | |
| | Amount of trust in crew members | | | | | | | | | 1 | 1 | | | |
| | Amount of trust in SVS | | | | | | | | | | | | | |
| | Amount of trust in systems other than the SVS | | | | | | | | | | | | | |
| | Current level of SA | | | | | | | | | 1 | 1 | | | |
| | Degree of pilot fatigue | | | | | | | | | 1 | 1 | | | |
| | Experience and ability of the pilot | | | | | 1 | | | | 1 | 1 | | | |
| | Experience using the SVS | | | | | | | | | 1 | 1 | | | |
| | Experience with terrain surrounding destination airport | | | | | | | | | 1 | 1 | | | |
| | Inference delay | | | | | | | | | | | | | |
| | Inference error | | | | | | | | | 1 | 1 | | | |
| | Level of mental workload | | | | | | | | | 1 | 1 | | | |
| | Level of self confidence | | | | | | | | | | | | | |
| | Number of errors in perceiving SVS data | | | | | | | | | 1 | 1 | | | |
| | Pilot error when using the SVS | | | | | | | | | 1 | 1 | | | |
| | Pilot experience with this specific approach | | | | | | | | | 1 | 1 | | | |
| | Pilot experience with this specific landing | | | | | | | | | 1 | 1 | | | |
| | Pilot preference | | | | | | | | | | | | | |
| | Pilots level of confidence in his/her perception of the SVS | | | | | | | | | | | | | |
| | Pilots level of confidence in his/her perception of the world | | | | | | | | | | | | | |
| | Pilots level of confidence in the accuracy of the SVS | | | | | | | | | | | | | |
| | Proximity to the destination airport | | | | | | | | | | | | | |
| **Machine** | Ability to declutter SVS display | | | | | | | | | 1 | 1 | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Accuracy of GPS | | 1 | | | 1 | | | | 1 | 1 | | | |
| Accuracy of terrain database | | 1 | | | 1 | | | | 1 | 1 | | | |
| Auditory vs. visual warning | | | | | | | | | 1 | 1 | | | |
| Color of symbols/text | | | | | | | | | 1 | 1 | | | |
| Color of terrain | | | | | | | | | 1 | 1 | | | |
| Degree of display clutter | | | | | | | | | 1 | 1 | | | |
| Degree of overlay with PFD data | | | | | | | | | 1 | 1 | | | |
| Display size | | | | | | | | | 1 | 1 | | | |
| Feedback delay | | | | | | | | | 1 | 1 | | | |
| FOV currently depicted on the SVS display | | | | | | | | | 1 | 1 | | | |
| Functioning/malfunctioning of hardware/software | | | | | | | | | 1 | 1 | | | |
| Glare on SVS | | | | | | | | | 1 | 1 | | | |
| Intuitiveness/usability of the SVS | | | | | | | | | 1 | 1 | | | |
| Layout of controls | | | | | | | | | 1 | 1 | | | |
| Limitations of the machines processor | | | | | | | | | 1 | 1 | | | |
| Location of the SVS display in the cockpit | | | | | | | | | 1 | 1 | | | |
| Number of highlighted features currently in view | | | | | | | | | 1 | 1 | | | |
| Number of key presses required to access desired information | | | | | | | | | 1 | 1 | | | |
| Number of layers in menu structure | | | | | | | | | 1 | 1 | | | |
| Number of obstacles currently in view | | | | | | | | | 1 | 1 | | | |
| Physical condition of display surfaces | | | | | | | | | 1 | 1 | | | |
| Pictorial scene information density | | | | | | | | | 1 | 1 | | | |
| Placement of controls | | | | | | | | | 1 | 1 | | | |
| Processing time (to display data from terrain database) | | | | | | | | | 1 | 1 | | | |
| Size of symbols/text | | | | | | | | | 1 | 1 | | | |
| Tactile feedback from controls | | | | | | | | | | | | | |
| Update rate of GPS | | | | | | | | | 1 | 1 | | | |
| Update rate of terrain database | | | | | | | | | 1 | 1 | | | |
| **SENSITIVITY TOTAL** | 0 | 9 | 0 | 0 | 14 | 0 | 0 | 1 | 61 | 62 | 0 | 0 | 1 |
| **SENSITIVITY RANK (2)** | 63 | 23.5 | 63 | 63 | 17.5 | 63 | 63 | 45 | 3 | 2 | 63 | 63 | 45 |

| Environment | | | | | | | | | | | | | | | | | | | | | | | | | | | | Pilot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

onment at destination airport
alfunctioning of displays other than the SVS
e on displays other than the SVS

| Lighting conditions in the cockpit | Physical state of the aircraft | Physical state of the engines | Speed of the aircraft (too low/high?) | Traffic situation at destination airport | Usability/intuitiveness of displays other than the SVS | Weather conditions at destination airport | Accuracy of pilots mental model of the environment | Accuracy of pilots mental model fo the SVS | Amount of collaboration with crew members | Amount of display cross-checking | Amount of time spent looking out-the-window | Amount of time spent reading instruments other than SVS | Amount of time spent viewing the SVS display | Amount of trust in crew members | Amount of trust in SVS | Amount of trust in systems other than the SVS | Current level of SA | Degree of pilot fatigue | Experience and ability of the pilot | Experience using the SVS | Experience with terrain surrounding destination airport | Inference delay | Inference error | Level of mental workload | Level of self confidence | Number of errors in percei | Pilot error when | Pilot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | | 1 | | | | 1 | | | | 1 | 1 | 1 | | | | 1 | | | | | | | 1 | 1 | | | |
| | | | | | | | 1 | 1 | | 1 | | 1 | 1 | | 1 | | 1 | | | | | | | 1 | 1 | 1 | 1 | |
| | | | | | | | | | | 1 | 1 | 1 | 1 | | | | 1 | | | | | | | 1 | | 1 | 1 | |
| | | | | | | | | | | 1 | 1 | 1 | 1 | | | | 1 | 1 | | | | | | 1 | 1 | 1 | 1 | |
| | | | | | | | | | | 1 | 1 | 1 | 1 | | | | 1 | 1 | | | | | | 1 | 1 | 1 | 1 | |
| | | | 1 | | | | 1 | | | 1 | 1 | 1 | 1 | | | | 1 | 1 | | | | | | 1 | 1 | 1 | 1 | |
| | | | 1 | | | | 1 | | | 1 | 1 | 1 | 1 | | | 1 | 1 | | | | | | | 1 | 1 | | | |
| | | | | | | | 1 | | | | | 1 | | | | | | | | | | | | 1 | 1 | | | |
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| | | | 1 | | | | 1 | | | | 1 | 1 | 1 | | | | 1 | | | | | | | 1 | 1 | | | |
| | | | | | | | | | | | | | | | 1 | 1 | 1 | | | | | | | 1 | | | | |
| | | | | | | | | | | | | | | | | | 1 | | | | | 1 | 1 | 1 | | 1 | 1 | |
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| | | | | | | | 1 | 1 | | | 1 | 1 | 1 | | 1 | 1 | 1 | | | | | | | 1 | 1 | | | |
| | | | | | | | 1 | 1 | | | | 1 | 1 | | 1 | 1 | 1 | | | | | | | 1 | 1 | 1 | | |
| | | | | | | | 1 | | | | 1 | | 1 | | | | 1 | | | | | | | 1 | 1 | | | |
| | | | | | | | 1 | 1 | | | 1 | 1 | | | 1 | | 1 | | | | | | | 1 | 1 | 1 | 1 | |
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| | | | | | | | 1 | 1 | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | |
| | | | | | | | | | | 1 | 1 | 1 | | | | | | | | | | | | 1 | | | | |
| | | | | | | | 1 | 1 | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | |
| | | | | | | | 1 | 1 | | | | | | | | | | | | | | 1 | 1 | | | 1 | 1 | |
| | | | | | | | 1 | 1 | | 1 | 1 | 1 | 1 | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | |
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| 0 | 0 | 0 | 9 | 0 | 0 | 0 | 44 | 31 | 4 | 28 | 43 | 52 | 51 | 1 | 8 | 5 | 46 | 8 | 0 | 2 | 0 | 9 | 9 | 63 | 18 | 32 | 31 | 0 |
| 63 | 63 | 63 | 23.5 | 63 | 63 | 63 | 7 | 11 | 35.5 | 13 | 8 | 4 | 5 | 45 | 27.5 | 32.5 | 6 | 27.5 | 63 | 40 | 63 | 23.5 | 23.5 | 1 | 15 | 9 | 11 | 63 |

eiving SVS data

n using the SVS

t experience with this specific approach

| | | | | | | Machine | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pilot expericence with this specific landing | Pilot preference | Pilots level of confidence in his/her perception of the SVS | Pilots level of confidence in his/her perception of the world | Pilots level of confidence in the accuracy of the SVS | Proximity to destination airport | Ability to declutter SVS display | Accuracy of GPS | Accuracy of terrain database | Auditory vs. visual warning | Color of symbols/text | Color of terrain | Degree of display clutter | Degree of overlay with PFD data | Display size | Feedback delay | FOV currently depicted on the SVS display | Functioning/malfunctioning of hardware/software | Glare on SVS | Intuitiveness/usability of the SVS | Layout of controls | Limiations of the machines processor | Location of the SVS display | Number of highlighted features currently in view | Number of key presses required to access desired | Number of layers in menu structure | Number of obstacles curren | Physical conditi | Pictori |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 0 | 0 | 14 | 21 | 15 | 0 | 0 | 0 | 0 | 9 | 6 | 6 | 11 | 11 | 9 | 4 | 6 | 0 | 0 | 31 | 4 | 0 | 4 | 0 | 2 | 1 | 1 | 0 | 5 |
| 63 | 63 | 17.5 | 14 | 16 | 63 | 63 | 63 | 63 | 23.5 | 30 | 30 | 19.5 | 19.5 | 23.5 | 35.5 | 30 | 63 | 63 | 11 | 35.5 | 63 | 35.5 | 63 | 40 | 45 | 45 | 63 | 32.5 |

1

…ed information

…ently in view

…tion of display surfaces

…orial scene information density

| Placement of controls | Processing time (to display data from terrain database) | Size of symbols/text | Tactile feedback from controls | Update rate of GPS | Update rate of terrain database | **INFLUENCE TOTAL** | **INFLUENCE (2)** |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | 15 | 16.5 |
| | | | | | | 4 | 69.5 |
| | | | | | | 12 | 30.5 |
| | | | | | | 4 | 69.5 |
| | | | | | | 0 | 77 |
| | | | | | | 14 | 22.5 |
| | | | | | | 14 | 22.5 |
| | | | | | | 13 | 27.5 |
| | | | | | | 20 | 5 |
| | | | | | | 19 | 7 |
| | | | | | | 24 | 2 |
| | | | | | | 17 | 9.5 |
| | | | | | | 7 | 53 |
| | | | | | | 1 | 75.5 |

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|---|---|---|---|---|---|---|---|
| | | | | | | 8 | 48 |
| | | | | | | 8 | 48 |
| | | | | | | 4 | 69.5 |
| | | | | | | 5 | 64 |
| | | | | | | 7 | 53 |
| | | | | | | 14 | 22.5 |
| | | | | | | 6 | 58.5 |
| | | | | | | 8 | 48 |
| | | | | | | 5 | 64 |
| | | | | | | 15 | 16.5 |
| | | | | | | 15 | 16.5 |
| | | | | | | 9 | 41.5 |
| | | | | | | 15 | 16.5 |
| | | | | | | 3 | 73.5 |
| | | | | | | 7 | 53 |
| | | | | | | 4 | 69.5 |
| | | | | | | 8 | 48 |
| | | | | | | 8 | 48 |
| | | | | | | 22 | 3 |
| | | | | | | 16 | 12.5 |
| | | | | | | 11 | 33.5 |
| | | | | | | 1 | 75.5 |
| | | | | | | 6 | 58.5 |
| | | | | | | 15 | 16.5 |
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| | | | | | | 6 | 58.5 |
| | | | | | | 11 | 33.5 |
| | | | | | | 11 | 33.5 |
| 1 | | 1 | | | | 17 | 9.5 |
| | | | | | | 4 | 69.5 |
| | | | | | | 4 | 69.5 |
| | | | | | | 7 | 53 |
| | | | | | | 6 | 58.5 |
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| | | | | | | 20 | 5 |
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| | | | | | | 13 | 27.5 |
| | | | | | | 14 | 22.5 |
| | | | | | | 12 | 30.5 |
| | | | | | | 14 | 22.5 |
| | | | | | | 15 | 16.5 |
| | | **1** | | | | 14 | 22.5 |
| | | | | | | 10 | 36.5 |
| | | | | | | 5 | 64 |
| | | | | | | 13 | 27.5 |
| | | | | | | 16 | 12.5 |
| **1** | | **1** | **1** | | | 30 | 1 |
| | | | | | | 7 | 53 |
| | **1** | | | | | 17 | 9.5 |
| | | | | | | 9 | 41.5 |
| | | | | | | 9 | 41.5 |
| | | | | | | 6 | 58.5 |
| | | | | | | 11 | 33.5 |
| | | | | | | 9 | 41.5 |
| | | | | | | 13 | 27.5 |
| | | | | | | 17 | 9.5 |
| | | | | | | 9 | 41.5 |
| | | | | | | 10 | 36.5 |
| | | | | | | 9 | 41.5 |
| | | | | | | 3 | 73.5 |
| | | | | | | 9 | 41.5 |
| | | | | | | 9 | 41.5 |
| 2 | 1 | 3 | 1 | 0 | 0 | | |
| 40 | 45 | 38 | 45 | 63 | 63 | | |

| | INFLUENCE TOTALS | SCORE | RANK | RANK (2) |
|---|---|---|---|---|
| m | Intuitiveness/usability of the SVS | 30 | 1 | 1 |
| w | Difficulty of terrain environment at destination airport | 24 | 2 | 2 |
| p | Experience and ability of the pilot | 22 | 3 | 3 |
| w | Difficulty of approach | 20 | 4 | 5 |
| m | Accuracy of GPS | 20 | 4 | 5 |
| m | Accuracy of terrain database | 20 | 4 | 5 |
| w | Difficulty of landing | 19 | 7 | 7 |
| w | Functioning/malfunctioning of displays other than the SVS | 17 | 8 | 9.5 |
| p | Pilot preference | 17 | 8 | 9.5 |
| m | Limitations of the machines processor | 17 | 8 | 9.5 |
| m | Pictorial scene information density | 17 | 8 | 9.5 |
| p | Experience using the SVS | 16 | 12 | 12.5 |
| m | Glare on SVS | 16 | 12 | 12.5 |
| w | Accuracy of information from displays other than the SVS | 15 | 14 | 16.5 |
| p | Amount of display cross-checking | 15 | 14 | 16.5 |
| p | Amount of time spent looking out-the-window | 15 | 14 | 16.5 |
| p | Amount of time spent viewing the SVS display | 15 | 14 | 16.5 |
| p | Level of mental workload | 15 | 14 | 16.5 |
| m | Degree of overlay with PFD data | 15 | 14 | 16.5 |
| w | Ceiling visibility at destination airport | 14 | 20 | 22.5 |
| w | Degree of redundant coding of SVS data | 14 | 20 | 22.5 |
| w | Weather conditions at destination airport | 14 | 20 | 22.5 |
| m | Color of symbols/text | 14 | 20 | 22.5 |
| m | Degree of display clutter | 14 | 20 | 22.5 |
| m | Display size | 14 | 20 | 22.5 |
| w | Degree of time pressure (is aircraft arriving on time, early) | 13 | 26 | 27.5 |
| m | Auditory vs. visual warning | 13 | 26 | 27.5 |
| m | Functioning/malfunctioning of hardware/software | 13 | 26 | 27.5 |
| m | Physical condition of display surfaces | 13 | 26 | 27.5 |
| w | Amount of information available from displays other SVS | 12 | 30 | 30.5 |
| m | Color of terrain | 12 | 30 | 30.5 |
| p | Experience with terrain surrounding destination airport | 11 | 32 | 33.5 |
| p | Pilot experience with this specific approach | 11 | 32 | 33.5 |
| p | Pilot experience with this specific landing | 11 | 32 | 33.5 |
| m | Number of layers in menu structure | 11 | 32 | 33.5 |
| m | Feedback delay | 10 | 36 | 36.5 |
| m | Processing time (to display data from terrain database) | 10 | 36 | 36.5 |
| p | Amount of time spent reading instruments other than the SVS | 9 | 38 | 41.5 |
| m | Location of the SVS display in the cockpit | 9 | 38 | 41.5 |
| m | Number of highlighted features currently in view | 9 | 38 | 41.5 |

| | | | | |
|---|---|---|---|---|
| m | Number of obstacles currently in view | 9 | 38 | 41.5 |
| m | Placement of controls | 9 | 38 | 41.5 |
| m | Size of symbols/text | 9 | 38 | 41.5 |
| m | Update rate of GPS | 9 | 38 | 41.5 |
| m | Update rate of terrain database | 9 | 38 | 41.5 |
| w | Physical state of the aircraft | 8 | 46 | 48 |
| w | Physical state of the engines | 8 | 46 | 48 |
| p | Accuracy of pilots mental model of the SVS | 8 | 46 | 48 |
| p | Current level of SA | 8 | 46 | 48 |
| p | Degree of pilot fatigue | 8 | 46 | 48 |
| w | Glare on displays other than the SVS | 7 | 51 | 53 |
| w | Usability/intuitiveness of displays other than the SVS | 7 | 51 | 53 |
| p | Amount of trust in SVS | 7 | 51 | 53 |
| p | Pilots level of confidence in the accuracy of the SVS | 7 | 51 | 53 |
| m | Layout of controls | 7 | 51 | 53 |
| p | Accuracy of pilots mental model of the environment | 6 | 56 | 58.5 |
| p | Inference error | 6 | 56 | 58.5 |
| p | Number of errors in perceiving SVS data | 6 | 56 | 58.5 |
| p | Pilot error when using the SVS | 6 | 56 | 58.5 |
| p | Proximity to the destination airport | 6 | 56 | 58.5 |
| m | Number of key presses required to access desired information | 6 | 56 | 58.5 |
| w | Traffic situation at destination airport | 5 | 62 | 64 |
| p | Amount of collaboration with crew members | 5 | 62 | 64 |
| p | Level of self confidence | 5 | 62 | 64 |
| m | Ability to declutter SVS display | 5 | 62 | 64 |
| m | FOV currently depicted on the SVS display | 5 | 62 | 64 |
| w | Altitude of the aircraft (too low/high?) | 4 | 67 | 69.5 |
| w | Amount of noise in cockpit | 4 | 67 | 69.5 |
| w | Speed of aircraft (too low/high?) | 4 | 67 | 69.5 |
| p | Amount of trust in systems other than the SVS | 4 | 67 | 69.5 |
| p | Pilots level of confidence in his/her perception of the SVS | 4 | 67 | 69.5 |
| p | Pilots level of confidence in his/her perception of the world | 4 | 67 | 69.5 |
| p | Amount of trust in crew members | 3 | 73 | 73.5 |
| m | Tactile feedback from controls | 3 | 73 | 73.5 |
| w | Lighting conditions in the cockpit | 1 | 75 | 75.5 |
| p | Inference delay | 1 | 75 | 75.5 |
| w | ATC workload | 0 | 77 | 77 |

| | SENSITIVITY TOTALS | SCORE | RANK | RANK (2) |
|---|---|---|---|---|
| m | Level of mental workload | 63 | 1 | 1 |
| m | Difficulty of landing | 62 | 2 | 2 |
| m | Difficulty of approach | 61 | 3 | 3 |
| m | Amount of time spent reading instruments other than the SVS | 52 | 4 | 4 |
| m | Amount of time spent viewing the SVS display | 51 | 5 | 5 |
| m | Current level of SA | 46 | 6 | 6 |
| m | Accuracy of pilots mental model of the environment | 44 | 7 | 7 |
| m | Amount of time spent looking out-the-window | 43 | 8 | 8 |
| m | Number of errors in perceiving SVS data | 32 | 9 | 9 |
| m | Intuitiveness/usability of the SVS | 31 | 10 | 11 |
| m | Accuracy of pilots mental model of the SVS | 31 | 10 | 11 |
| m | Pilot error when using the SVS | 31 | 10 | 11 |
| m | Amount of display cross-checking | 28 | 13 | 13 |
| m | Pilots level of confidence in his/her perception of the world | 21 | 14 | 14 |
| m | Level of self confidence | 18 | 15 | 15 |
| m | Pilots level of confidence in the accuracy of the SVS | 15 | 16 | 16 |
| m | Pilots level of confidence in his/her perception of the SVS | 14 | 17 | 17.5 |
| m | ATC workload | 14 | 17 | 17.5 |
| m | Degree of display clutter | 11 | 19 | 19.5 |
| m | Degree of overlay with PFD data | 11 | 19 | 19.5 |
| m | Auditory vs. visual warning | 9 | 21 | 23.5 |
| m | Display size | 9 | 21 | 23.5 |
| m | Inference delay | 9 | 21 | 23.5 |
| m | Inference error | 9 | 21 | 23.5 |
| m | Altitude of the aircraft (too low/high?) | 9 | 21 | 23.5 |
| m | Speed of aircraft (too low/high?) | 9 | 21 | 23.5 |
| m | Amount of trust in SVS | 8 | 27 | 27.5 |
| m | Degree of pilot fatigue | 8 | 27 | 27.5 |
| m | Color of symbols/text | 6 | 29 | 30 |
| p | Color of terrain | 6 | 29 | 30 |
| p | FOV currently depicted on the SVS display | 6 | 29 | 30 |
| p | Pictorial scene information density | 5 | 32 | 32.5 |
| p | Amount of trust in systems other than the SVS | 5 | 32 | 32.5 |
| p | Feedback delay | 4 | 34 | 35.5 |
| p | Layout of controls | 4 | 34 | 35.5 |
| p | Location of the SVS display in the cockpit | 4 | 34 | 35.5 |
| p | Amount of collaboration with crew members | 4 | 34 | 35.5 |
| p | Size of symbols/text | 3 | 38 | 38 |
| p | Number of key presses required to access desired information | 2 | 39 | 40 |
| p | Placement of controls | 2 | 39 | 40 |

| | | | | |
|---|---|---|---|---|
| p | Experience using the SVS | 2 | 39 | 40 |
| p | Number of layers in menu structure | 1 | 42 | 45 |
| p | Number of obstacles currently in view | 1 | 42 | 45 |
| p | Processing time (to display data from terrain database) | 1 | 42 | 45 |
| p | Tactile feedback from controls | 1 | 42 | 45 |
| p | Amount of trust in crew members | 1 | 42 | 45 |
| p | Degree of time pressure (is aircraft arriving on time, early) | 1 | 42 | 45 |
| p | Glare on displays other than the SVS | 1 | 42 | 45 |
| p | Ability to declutter SVS display | 0 | 49 | 63 |
| p | Accuracy of GPS | 0 | 49 | 63 |
| p | Accuracy of terrain database | 0 | 49 | 63 |
| p | Functioning/malfunctioning of hardware/software | 0 | 49 | 63 |
| p | Glare on SVS | 0 | 49 | 63 |
| p | Limitations of the machines processor | 0 | 49 | 63 |
| p | Number of highlighted features currently in view | 0 | 49 | 63 |
| p | Physical condition of display surfaces | 0 | 49 | 63 |
| p | Update rate of GPS | 0 | 49 | 63 |
| w | Update rate of terrain database | 0 | 49 | 63 |
| w | Experience and ability of the pilot | 0 | 49 | 63 |
| w | Experience with terrain surrounding destination airport | 0 | 49 | 63 |
| w | Pilot experience with this specific approach | 0 | 49 | 63 |
| w | Pilot experience with this specific landing | 0 | 49 | 63 |
| w | Pilot preference | 0 | 49 | 63 |
| w | Proximity to the destination airport | 0 | 49 | 63 |
| w | Accuracy of information from displays other than the SVS | 0 | 49 | 63 |
| w | Amount of information available from displays other SVS | 0 | 49 | 63 |
| w | Amount of noise in cockpit | 0 | 49 | 63 |
| w | Ceiling visibility at destination airport | 0 | 49 | 63 |
| w | Degree of redundant coding of SVS data | 0 | 49 | 63 |
| w | Difficulty of terrain environment at destination airport | 0 | 49 | 63 |
| w | Functioning/malfunctioning of displays other than the SVS | 0 | 49 | 63 |
| w | Lighting conditions in the cockpit | 0 | 49 | 63 |
| w | Physical state of the aircraft | 0 | 49 | 63 |
| w | Physical state of the engines | 0 | 49 | 63 |
| w | Traffic situation at destination airport | 0 | 49 | 63 |
| w | Usability/intuitiveness of displays other than the SVS | 0 | 49 | 63 |
| w | Weather conditions at destination airport | 0 | 49 | 63 |

| INFLUENCE TOTALS | SCORE | RANK | RANK (2) |
|---|---|---|---|
| **Environment** | | | |
| Difficulty of terrain environment at destination airport | 24 | 2 | 2 |
| Difficulty of approach | 20 | 4 | 5 |
| Difficulty of landing | 19 | 7 | 7 |
| Functioning/malfunctioning of displays other than the SVS | 17 | 8 | 9.5 |
| Accuracy of information from displays other than the SVS | 15 | 14 | 16.5 |
| Ceiling visibility at destination airport | 14 | 20 | 22.5 |
| Degree of redundant coding of SVS data | 14 | 20 | 22.5 |
| Weather conditions at destination airport | 14 | 20 | 22.5 |
| Degree of time pressure (is aircraft arriving on time, early) | 13 | 26 | 27.5 |
| Amount of information available from displays other SVS | 12 | 30 | 30.5 |
| Physical state of the aircraft | 8 | 46 | 48 |
| Physical state of the engines | 8 | 46 | 48 |
| Glare on displays other than the SVS | 7 | 51 | 53 |
| Usability/intuitiveness of displays other than the SVS | 7 | 51 | 53 |
| Traffic situation at destination airport | 5 | 62 | 64 |
| Altitude of the aircraft (too low/high?) | 4 | 67 | 69.5 |
| Amount of noise in cockpit | 4 | 67 | 69.5 |
| Speed of aircraft (too low/high?) | 4 | 67 | 69.5 |
| Lighting conditions in the cockpit | 1 | 75 | 75.5 |
| ATC workload | 0 | 77 | 77 |
| **Pilot** | | | |
| Experience and ability of the pilot | 22 | 3 | 3 |
| Pilot preference | 17 | 8 | 9.5 |
| Experience using the SVS | 16 | 12 | 12.5 |
| Amount of display cross-checking | 15 | 14 | 16.5 |
| Amount of time spent looking out-the-window | 15 | 14 | 16.5 |
| Amount of time spent viewing the SVS display | 15 | 14 | 16.5 |
| Level of mental workload | 15 | 14 | 16.5 |
| Experience with terrain surrounding destination airport | 11 | 32 | 33.5 |
| Pilot experience with this specific approach | 11 | 32 | 33.5 |
| Pilot experience with this specific landing | 11 | 32 | 33.5 |
| Amount of time spent reading instruments other than the S | 9 | 38 | 41.5 |
| Accuracy of pilots mental model of the SVS | 8 | 46 | 48 |
| Current level of SA | 8 | 46 | 48 |
| Degree of pilot fatigue | 8 | 46 | 48 |
| Amount of trust in SVS | 7 | 51 | 53 |
| Pilots level of confidence in the accuracy of the SVS | 7 | 51 | 53 |
| Accuracy of pilots mental model of the environment | 6 | 56 | 58.5 |

| | | | |
|---|---|---|---|
| Inference error | 6 | 56 | 58.5 |
| Number of errors in perceiving SVS data | 6 | 56 | 58.5 |
| Pilot error when using the SVS | 6 | 56 | 58.5 |
| Proximity to the destination airport | 6 | 56 | 58.5 |
| Amount of collaboration with crew members | 5 | 62 | 64 |
| Level of self confidence | 5 | 62 | 64 |
| Amount of trust in systems other than the SVS | 4 | 67 | 69.5 |
| Pilots level of confidence in his/her perception of the SVS | 4 | 67 | 69.5 |
| Pilots level of confidence in his/her perception of the world | 4 | 67 | 69.5 |
| Amount of trust in crew members | 3 | 73 | 73.5 |
| Inference delay | 1 | 75 | 75.5 |
| **Machine** | | | |
| Intuitiveness/usability of the SVS | 30 | 1 | 1 |
| Accuracy of GPS | 20 | 4 | 5 |
| Accuracy of terrain database | 20 | 4 | 5 |
| Limitations of the machines processor | 17 | 8 | 9.5 |
| Pictorial scene information density | 17 | 8 | 9.5 |
| Glare on SVS | 16 | 12 | 12.5 |
| Degree of overlay with PFD data | 15 | 14 | 16.5 |
| Color of symbols/text | 14 | 20 | 22.5 |
| Degree of display clutter | 14 | 20 | 22.5 |
| Display size | 14 | 20 | 22.5 |
| Auditory vs. visual warning | 13 | 26 | 27.5 |
| Functioning/malfunctioning of hardware/software | 13 | 26 | 27.8 |
| Physical condition of display surfaces | 13 | 26 | 27.8 |
| Color of terrain | 12 | 30 | 30.5 |
| Number of layers in menu structure | 11 | 32 | 33.5 |
| Feedback delay | 10 | 36 | 36.5 |
| Processing time (to display data from terrain database) | 10 | 36 | 36.5 |
| Location of the SVS display in the cockpit | 9 | 38 | 41.5 |
| Number of highlighted features currently in view | 9 | 38 | 41.5 |
| Number of obstacles currently in view | 9 | 38 | 41.5 |
| Placement of controls | 9 | 38 | 41.5 |
| Size of symbols/text | 9 | 38 | 41.5 |
| Update rate of GPS | 9 | 38 | 41.5 |
| Update rate of terrain database | 9 | 38 | 41.5 |
| Layout of controls | 7 | 51 | 53 |
| Number of key presses required to access desired informati | 6 | 56 | 58.5 |
| Ability to declutter SVS display | 5 | 62 | 64 |
| FOV currently depicted on the SVS display | 5 | 62 | 64 |
| Tactile feedback from controls | 3 | 73 | 73.5 |

| SENSITIVITY TOTALS | SCORE | RANK | RANK (2) |
|---|---|---|---|
| Environment | | | |
| Difficulty of approach | 61 | 3 | 3 |
| ATC workload | 14 | 17 | 17.5 |
| Altitude of the aircraft (too low/high?) | 9 | 21 | 23.5 |
| Speed of aircraft (too low/high?) | 9 | 21 | 23.5 |
| Degree of time pressure (is aircraft arriving on time, early) | 1 | 42 | 45 |
| Glare on displays other than the SVS | 1 | 42 | 45 |
| Accuracy of information from displays other than the SVS | 0 | 49 | 63 |
| Amount of information available from displays other SVS | 0 | 49 | 63 |
| Amount of noise in cockpit | 0 | 49 | 63 |
| Ceiling visibility at destination airport | 0 | 49 | 63 |
| Degree of redundant coding of SVS data | 0 | 49 | 63 |
| Difficulty of terrain environment at destination airport | 0 | 49 | 63 |
| Functioning/malfunctioning of displays other than the SVS | 0 | 49 | 63 |
| Lighting conditions in the cockpit | 0 | 49 | 63 |
| Physical state of the aircraft | 0 | 49 | 63 |
| Physical state of the engines | 0 | 49 | 63 |
| Traffic situation at destination airport | 0 | 49 | 63 |
| Usability/intuitiveness of displays other than the SVS | 0 | 49 | 63 |
| Weather conditions at destination airport | 0 | 49 | 63 |
| Pilot | | | |
| Level of mental workload | 63 | 1 | 1 |
| Amount of time spent reading instruments other than the S | 52 | 4 | 4 |
| Amount of time spent viewing the SVS display | 51 | 5 | 5 |
| Current level of SA | 46 | 6 | 6 |
| Accuracy of pilots mental model of the environment | 44 | 7 | 7 |
| Amount of time spent looking out-the-window | 43 | 8 | 8 |
| Number of errors in perceiving SVS data | 32 | 9 | 9 |
| Accuracy of pilots mental model of the SVS | 31 | 10 | 11 |
| Pilot error when using the SVS | 31 | 10 | 11 |
| Amount of display cross-checking | 28 | 13 | 13 |
| Pilots level of confidence in his/her perception of the world | 21 | 14 | 14 |
| Level of self confidence | 18 | 15 | 15 |
| Pilots level of confidence in the accuracy of the SVS | 15 | 16 | 16 |
| Pilots level of confidence in his/her perception of the SVS | 14 | 17 | 17.5 |
| Inference delay | 9 | 21 | 23.5 |
| Inference error | 9 | 21 | 23.5 |
| Amount of trust in SVS | 8 | 27 | 27.5 |

| | | | |
|---|---|---|---|
| Degree of pilot fatigue | 8 | 27 | 27.5 |
| Amount of trust in systems other than the SVS | 5 | 32 | 32.5 |
| Amount of collaboration with crew members | 4 | 34 | 35.5 |
| Experience using the SVS | 2 | 39 | 40 |
| Amount of trust in crew members | 1 | 42 | 45 |
| Experience and ability of the pilot | 0 | 49 | 63 |
| Experience with terrain surrounding destination airport | 0 | 49 | 63 |
| Pilot experience with this specific approach | 0 | 49 | 63 |
| Pilot experience with this specific landing | 0 | 49 | 63 |
| Pilot preference | 0 | 49 | 63 |
| Proximity to the destination airport | 0 | 49 | 63 |
| Machine | | | |
| Intuitiveness/usability of the SVS | 31 | 10 | 11 |
| Degree of display clutter | 11 | 19 | 19.5 |
| Degree of overlay with PFD data | 11 | 19 | 19.5 |
| Auditory vs. visual warning | 9 | 21 | 23.5 |
| Display size | 9 | 21 | 23.5 |
| Color of symbols/text | 6 | 29 | 30 |
| Color of terrain | 6 | 29 | 30 |
| FOV currently depicted on the SVS display | 6 | 29 | 30 |
| Pictorial scene information density | 5 | 32 | 32.5 |
| Feedback delay | 4 | 34 | 35.5 |
| Layout of controls | 4 | 34 | 35.5 |
| Location of the SVS display in the cockpit | 4 | 34 | 35.5 |
| Size of symbols/text | 3 | 38 | 38 |
| Number of key presses required to access desired informati | 2 | 39 | 40 |
| Placement of controls | 2 | 39 | 40 |
| Number of layers in menu structure | 1 | 42 | 45 |
| Number of obstacles currently in view | 1 | 42 | 45 |
| Processing time (to display data from terrain database) | 1 | 42 | 45 |
| Tactile feedback from controls | 1 | 42 | 45 |
| Ability to declutter SVS display | 0 | 49 | 63 |
| Accuracy of GPS | 0 | 49 | 63 |
| Accuracy of terrain database | 0 | 49 | 63 |
| Functioning/malfunctioning of hardware/software | 0 | 49 | 63 |
| Glare on SVS | 0 | 49 | 63 |
| Limitations of the machines processor | 0 | 49 | 63 |
| Number of highlighted features currently in view | 0 | 49 | 63 |
| Physical condition of display surfaces | 0 | 49 | 63 |
| Update rate of GPS | 0 | 49 | 63 |
| Update rate of terrain database | 0 | 49 | 63 |

**Appendix E**

| INFLUENCE TOTALS | SCORE | RANK |
|---|---|---|
| **Environment** | | |
| Difficulty of terrain environment at destination airport | 24 | 2 |
| Difficulty of approach | 20 | 5 |
| Difficulty of landing | 19 | 7 |
| Functioning/malfunctioning of displays other than the SVS | 17 | 9.5 |
| Accuracy of information from displays other than the SVS | 15 | 16.5 |
| Ceiling visibility at destination airport | 14 | 22.5 |
| Degree of redundant coding of SVS data | 14 | 22.5 |
| Weather conditions at destination airport | 14 | 22.5 |
| Degree of time pressure (is aircraft arriving on time, early) | 13 | 27.5 |
| Amount of information available from displays other SVS | 12 | 30.5 |
| Physical state of the aircraft | 8 | 48 |
| Physical state of the engines | 8 | 48 |
| Glare on displays other than the SVS | 7 | 53 |
| Usability/intuitiveness of displays other than the SVS | 7 | 53 |
| Traffic situation at destination airport | 5 | 64 |
| Altitude of the aircraft (too low/high?) | 4 | 69.5 |
| Amount of noise in cockpit | 4 | 69.5 |
| Speed of aircraft (too low/high?) | 4 | 69.5 |
| Lighting conditions in the cockpit | 1 | 75.5 |
| ATC workload | 0 | 77 |
| **Pilot** | | |
| Experience and ability of the pilot | 22 | 3 |
| Pilot preference | 17 | 9.5 |
| Experience using the SVS | 16 | 12.5 |
| Amount of display cross-checking | 15 | 16.5 |
| Amount of time spent looking out-the-window | 15 | 16.5 |
| Amount of time spent viewing the SVS display | 15 | 16.5 |
| Level of mental workload | 15 | 16.5 |
| Experience with terrain surrounding destination airport | 11 | 33.5 |
| Pilot experience with this specific approach | 11 | 33.5 |
| Pilot experience with this specific landing | 11 | 33.5 |
| Amount of time spent reading instruments other than the SVS | 9 | 41.5 |
| Accuracy of pilots mental model of the SVS | 8 | 48 |
| Current level of SA | 8 | 48 |
| Degree of pilot fatigue | 8 | 48 |
| Amount of trust in SVS | 7 | 53 |
| Pilots level of confidence in the accuracy of the SVS | 7 | 53 |
| Accuracy of pilots mental model of the environment | 6 | 58.5 |
| Inference error | 6 | 58.5 |

## Appendix E

| | | |
|---|---|---|
| Number of errors in perceiving SVS data | 6 | 58.5 |
| Pilot error when using the SVS | 6 | 58.5 |
| Proximity to the destination airport | 6 | 58.5 |
| Amount of collaboration with crew members | 5 | 64 |
| Level of self confidence | 5 | 64 |
| Amount of trust in systems other than the SVS | 4 | 69.5 |
| Pilots level of confidence in his/her perception of the SVS | 4 | 69.5 |
| Pilots level of confidence in his/her perception of the world | 4 | 69.5 |
| Amount of trust in crew members | 3 | 73.5 |
| Inference delay | 1 | 75.5 |
| Machine | | |
| Intuitiveness/usability of the SVS | 30 | 1 |
| Accuracy of GPS | 20 | 5 |
| Accuracy of terrain database | 20 | 5 |
| Limitations of the machines processor | 17 | 9.5 |
| Pictorial scene information density | 17 | 9.5 |
| Glare on SVS | 16 | 12.5 |
| Degree of overlay with PFD data | 15 | 16.5 |
| Color of symbols/text | 14 | 22.5 |
| Degree of display clutter | 14 | 22.5 |
| Display size | 14 | 22.5 |
| Auditory vs. visual warning | 13 | 27.5 |
| Functioning/malfunctioning of hardware/software | 13 | 27.8 |
| Physical condition of display surfaces | 13 | 27.8 |
| Color of terrain | 12 | 30.5 |
| Number of layers in menu structure | 11 | 33.5 |
| Feedback delay | 10 | 36.5 |
| Processing time (to display data from terrain database) | 10 | 36.5 |
| Location of the SVS display in the cockpit | 9 | 41.5 |
| Number of highlighted features currently in view | 9 | 41.5 |
| Number of obstacles currently in view | 9 | 41.5 |
| Placement of controls | 9 | 41.5 |
| Size of symbols/text | 9 | 41.5 |
| Update rate of GPS | 9 | 41.5 |
| Update rate of terrain database | 9 | 41.5 |
| Layout of controls | 7 | 53 |
| Number of key presses required to access desired information | 6 | 58.5 |
| Ability to declutter SVS display | 5 | 64 |
| FOV currently depicted on the SVS display | 5 | 64 |
| Tactile feedback from controls | 3 | 73.5 |

## Appendix E

| SENSITIVITY TOTALS | SCORE | RANK |
|---|---|---|
| **Environment** | | |
| Difficulty of approach | 61 | 3 |
| ATC workload | 14 | 17.5 |
| Altitude of the aircraft (too low/high?) | 9 | 23.5 |
| Speed of aircraft (too low/high?) | 9 | 23.5 |
| Degree of time pressure (is aircraft arriving on time, early) | 1 | 45 |
| Glare on displays other than the SVS | 1 | 45 |
| Accuracy of information from displays other than the SVS | 0 | 63 |
| Amount of information available from displays other SVS | 0 | 63 |
| Amount of noise in cockpit | 0 | 63 |
| Ceiling visibility at destination airport | 0 | 63 |
| Degree of redundant coding of SVS data | 0 | 63 |
| Difficulty of terrain environment at destination airport | 0 | 63 |
| Functioning/malfunctioning of displays other than the SVS | 0 | 63 |
| Lighting conditions in the cockpit | 0 | 63 |
| Physical state of the aircraft | 0 | 63 |
| Physical state of the engines | 0 | 63 |
| Traffic situation at destination airport | 0 | 63 |
| Usability/intuitiveness of displays other than the SVS | 0 | 63 |
| Weather conditions at destination airport | 0 | 63 |
| **Pilot** | | |
| Level of mental workload | 63 | 1 |
| Amount of time spent reading instruments other than the SVS | 52 | 4 |
| Amount of time spent viewing the SVS display | 51 | 5 |
| Current level of SA | 46 | 6 |
| Accuracy of pilots mental model of the environment | 44 | 7 |
| Amount of time spent looking out-the-window | 43 | 8 |
| Number of errors in perceiving SVS data | 32 | 9 |
| Accuracy of pilots mental model of the SVS | 31 | 11 |
| Pilot error when using the SVS | 31 | 11 |
| Amount of display cross-checking | 28 | 13 |
| Pilots level of confidence in his/her perception of the world | 21 | 14 |
| Level of self confidence | 18 | 15 |
| Pilots level of confidence in the accuracy of the SVS | 15 | 16 |
| Pilots level of confidence in his/her perception of the SVS | 14 | 17.5 |
| Inference delay | 9 | 23.5 |
| Inference error | 9 | 23.5 |
| Amount of trust in SVS | 8 | 27.5 |
| Degree of pilot fatigue | 8 | 27.5 |

## Appendix E

| | | |
|---|---|---|
| Amount of trust in systems other than the SVS | 5 | 32.5 |
| Amount of collaboration with crew members | 4 | 35.5 |
| Experience using the SVS | 2 | 40 |
| Amount of trust in crew members | 1 | 45 |
| Experience and ability of the pilot | 0 | 63 |
| Experience with terrain surrounding destination airport | 0 | 63 |
| Pilot experience with this specific approach | 0 | 63 |
| Pilot experience with this specific landing | 0 | 63 |
| Pilot preference | 0 | 63 |
| Proximity to the destination airport | 0 | 63 |
| **Machine** | | |
| Intuitiveness/usability of the SVS | 31 | 11 |
| Degree of display clutter | 11 | 19.5 |
| Degree of overlay with PFD data | 11 | 19.5 |
| Auditory vs. visual warning | 9 | 23.5 |
| Display size | 9 | 23.5 |
| Color of symbols/text | 6 | 30 |
| Color of terrain | 6 | 30 |
| FOV currently depicted on the SVS display | 6 | 30 |
| Pictorial scene information density | 5 | 32.5 |
| Feedback delay | 4 | 35.5 |
| Layout of controls | 4 | 35.5 |
| Location of the SVS display in the cockpit | 4 | 35.5 |
| Size of symbols/text | 3 | 38 |
| Number of key presses required to access desired information | 2 | 40 |
| Placement of controls | 2 | 40 |
| Number of layers in menu structure | 1 | 45 |
| Number of obstacles currently in view | 1 | 45 |
| Processing time (to display data from terrain database) | 1 | 45 |
| Tactile feedback from controls | 1 | 45 |
| Ability to declutter SVS display | 0 | 63 |
| Accuracy of GPS | 0 | 63 |
| Accuracy of terrain database | 0 | 63 |
| Functioning/malfunctioning of hardware/software | 0 | 63 |
| Glare on SVS | 0 | 63 |
| Limitations of the machines processor | 0 | 63 |
| Number of highlighted features currently in view | 0 | 63 |
| Physical condition of display surfaces | 0 | 63 |
| Update rate of GPS | 0 | 63 |
| Update rate of terrain database | 0 | 63 |

| INFLUENCE TOTALS | SCORE | RANK |
| --- | --- | --- |
| Ability to declutter SVS display | 5 | 62 |
| Accuracy of GPS | 20 | 4 |
| Accuracy of information from displays other than the SVS | 15 | 14 |
| Accuracy of pilots mental model of the environment | 6 | 56 |
| Accuracy of pilots mental model of the SVS | 8 | 46 |
| Accuracy of terrain database | 20 | 4 |
| Altitude of the aircraft (too low/high?) | 4 | 67 |
| Amount of collaboration with crew members | 5 | 62 |
| Amount of display cross-checking | 15 | 14 |
| Amount of information available from displays other SVS | 12 | 30 |
| Amount of noise in cockpit | 4 | 67 |
| Amount of time spent looking out-the-window | 15 | 14 |
| Amount of time spent reading instruments other than the SVS | 9 | 38 |
| Amount of time spent viewing the SVS display | 15 | 14 |
| Amount of trust in crew members | 3 | 73 |
| Amount of trust in SVS | 7 | 51 |
| Amount of trust in systems other than the SVS | 4 | 67 |
| ATC workload | 0 | 77 |
| Auditory vs. visual warning | 13 | 26 |
| Ceiling visibility at destination airport | 14 | 20 |
| Color of symbols/text | 14 | 20 |
| Color of terrain | 12 | 30 |
| Current level of SA | 8 | 46 |
| Degree of display clutter | 14 | 20 |
| Degree of overlay with PFD data | 15 | 14 |
| Degree of pilot fatigue | 8 | 46 |
| Degree of redundant coding of SVS data | 14 | 20 |
| Degree of time pressure (is aircraft arriving on time, early) | 13 | 26 |
| Difficulty of approach | 20 | 4 |
| Difficulty of landing | 19 | 7 |
| Difficulty of terrain environment at destination airport | 24 | 2 |
| Display size | 14 | 20 |
| Experience and ability of the pilot | 22 | 3 |
| Experience using the SVS | 16 | 12 |
| Experience with terrain surrounding destination airport | 11 | 32 |
| Feedback delay | 10 | 36 |
| FOV currently depicted on the SVS display | 5 | 62 |
| Functioning/malfunctioning of displays other than the SVS | 17 | 8 |
| Functioning/malfunctioning of hardware/software | 13 | 26 |
| Glare on displays other than the SVS | 7 | 51 |

| | | |
|---|---|---|
| Glare on SVS | 16 | 12 |
| Inference delay | 1 | 75 |
| Inference error | 6 | 56 |
| Intuitiveness/usability of the SVS | 30 | 1 |
| Layout of controls | 7 | 51 |
| Level of mental workload | 15 | 14 |
| Level of self confidence | 5 | 62 |
| Lighting conditions in the cockpit | 1 | 75 |
| Limitations of the machines processor | 17 | 8 |
| Location of the SVS display in the cockpit | 9 | 38 |
| Number of errors in perceiving SVS data | 6 | 56 |
| Number of highlighted features currently in view | 9 | 38 |
| Number of key presses required to access desired information | 6 | 56 |
| Number of layers in menu structure | 11 | 32 |
| Number of obstacles currently in view | 9 | 38 |
| Physical condition of display surfaces | 13 | 26 |
| Physical state of the aircraft | 8 | 46 |
| Physical state of the engines | 8 | 46 |
| Pictorial scene information density | 17 | 8 |
| Pilot error when using the SVS | 6 | 56 |
| Pilot experience with this specific approach | 11 | 32 |
| Pilot experience with this specific landing | 11 | 32 |
| Pilot preference | 17 | 8 |
| Pilots level of confidence in his/her perception of the SVS | 4 | 67 |
| Pilots level of confidence in his/her perception of the world | 4 | 67 |
| Pilots level of confidence in the accuracy of the SVS | 7 | 51 |
| Placement of controls | 9 | 38 |
| Processing time (to display data from terrain database) | 10 | 36 |
| Proximity to the destination airport | 6 | 56 |
| Size of symbols/text | 9 | 38 |
| Speed of aircraft (too low/high?) | 4 | 67 |
| Tactile feedback from controls | 3 | 73 |
| Traffic situation at destination airport | 5 | 62 |
| Update rate of GPS | 9 | 38 |
| Update rate of terrain database | 9 | 38 |
| Usability/intuitiveness of displays other than the SVS | 7 | 51 |
| Weather conditions at destination airport | 14 | 20 |

| SENSITIVITY TOTALS | SCORE | RANK |
|---|---|---|
| Ability to declutter SVS display | 0 | 49 |
| Accuracy of GPS | 0 | 49 |

| | | |
|---|---|---|
| Accuracy of information from displays other than the SVS | 0 | 49 |
| Accuracy of pilots mental model of the environment | 44 | 7 |
| Accuracy of pilots mental model of the SVS | 31 | 10 |
| Accuracy of terrain database | 0 | 49 |
| Altitude of the aircraft (too low/high?) | 9 | 21 |
| Amount of collaboration with crew members | 4 | 34 |
| Amount of display cross-checking | 28 | 13 |
| Amount of information available from displays other SVS | 0 | 49 |
| Amount of noise in cockpit | 0 | 49 |
| Amount of time spent looking out-the-window | 43 | 8 |
| Amount of time spent reading instruments other than the SVS | 52 | 4 |
| Amount of time spent viewing the SVS display | 51 | 5 |
| Amount of trust in crew members | 1 | 42 |
| Amount of trust in SVS | 8 | 27 |
| Amount of trust in systems other than the SVS | 5 | 32 |
| ATC workload | 14 | 17 |
| Auditory vs. visual warning | 9 | 21 |
| Ceiling visibility at destination airport | 0 | 49 |
| Color of symbols/text | 6 | 29 |
| Color of terrain | 6 | 29 |
| Current level of SA | 46 | 6 |
| Degree of display clutter | 11 | 19 |
| Degree of overlay with PFD data | 11 | 19 |
| Degree of pilot fatigue | 8 | 27 |
| Degree of redundant coding of SVS data | 0 | 49 |
| Degree of time pressure (is aircraft arriving on time, early) | 1 | 42 |
| Difficulty of approach | 61 | 3 |
| Difficulty of landing | 62 | 2 |
| Difficulty of terrain environment at destination airport | 0 | 49 |
| Display size | 9 | 21 |
| Experience and ability of the pilot | 0 | 49 |
| Experience using the SVS | 2 | 39 |
| Experience with terrain surrounding destination airport | 0 | 49 |
| Feedback delay | 4 | 34 |
| FOV currently depicted on the SVS display | 6 | 29 |
| Functioning/malfunctioning of displays other than the SVS | 0 | 49 |
| Functioning/malfunctioning of hardware/software | 0 | 49 |
| Glare on displays other than the SVS | 1 | 42 |
| Glare on SVS | 0 | 49 |
| Inference delay | 9 | 21 |
| Inference error | 9 | 21 |
| Intuitiveness/usability of the SVS | 31 | 10 |

| | | |
|---|---|---|
| Layout of controls | 4 | 34 |
| Level of mental workload | 63 | 1 |
| Level of self confidence | 18 | 15 |
| Lighting conditions in the cockpit | 0 | 49 |
| Limitations of the machines processor | 0 | 49 |
| Location of the SVS display in the cockpit | 4 | 34 |
| Number of errors in perceiving SVS data | 32 | 9 |
| Number of highlighted features currently in view | 0 | 49 |
| Number of key presses required to access desired information | 2 | 39 |
| Number of layers in menu structure | 1 | 42 |
| Number of obstacles currently in view | 1 | 42 |
| Physical condition of display surfaces | 0 | 49 |
| Physical state of the aircraft | 0 | 49 |
| Physical state of the engines | 0 | 49 |
| Pictorial scene information density | 5 | 32 |
| Pilot error when using the SVS | 31 | 10 |
| Pilot experience with this specific approach | 0 | 49 |
| Pilot experience with this specific landing | 0 | 49 |
| Pilot preference | 0 | 49 |
| Pilots level of confidence in his/her perception of the SVS | 14 | 17 |
| Pilots level of confidence in his/her perception of the world | 21 | 14 |
| Pilots level of confidence in the accuracy of the SVS | 15 | 16 |
| Placement of controls | 2 | 39 |
| Processing time (to display data from terrain database) | 1 | 42 |
| Proximity to the destination airport | 0 | 49 |
| Size of symbols/text | 3 | 38 |
| Speed of aircraft (too low/high?) | 9 | 21 |
| Tactile feedback from controls | 1 | 42 |
| Traffic situation at destination airport | 0 | 49 |
| Update rate of GPS | 0 | 49 |
| Update rate of terrain database | 0 | 49 |
| Usability/intuitiveness of displays other than the SVS | 0 | 49 |
| Weather conditions at destination airport | 0 | 49 |

| TOP FIFTEEN CHARACTERISTICS (INFLUENCE) | SCORE | RANK |
|---|---|---|
| Intuitiveness/usability of the SVS | 30 | 1 |
| Difficulty of terrain environment at destination airport | 24 | 2 |
| Experience and ability of the pilot | 22 | 3 |
| Difficulty of approach | 20 | 4 |
| Accuracy of GPS | 20 | 4 |

| | | |
|---|---|---|
| Accuracy of terrain database | 20 | 4 |
| Difficulty of landing | 19 | 7 |
| Functioning/malfunctioning of displays other than the SVS | 17 | 8 |
| Pilot preference | 17 | 8 |
| Limitations of the machines processor | 17 | 8 |
| Pictorial scene information density | 17 | 8 |
| Experience using the SVS | 16 | 12 |
| Glare on SVS | 16 | 12 |
| Accuracy of information from displays other than the SVS | 15 | 14 |
| Amount of display cross-checking | 15 | 14 |

| TOP FIFTEEN CHARACTERISTICS (SENSITIVITY) | SCORE | RANK |
|---|---|---|
| Level of mental workload | 63 | 1 |
| Difficulty of landing | 62 | 2 |
| Difficulty of approach | 61 | 3 |
| Amount of time spent reading instruments other than the SVS | 52 | 4 |
| Amount of time spent viewing the SVS display | 51 | 5 |
| Current level of SA | 46 | 6 |
| Accuracy of pilots mental model of the environment | 44 | 7 |
| Amount of time spent looking out-the-window | 43 | 8 |
| Number of errors in perceiving SVS data | 32 | 9 |
| Accuracy of pilots mental model of the SVS | 31 | 10 |
| Pilot error when using the SVS | 31 | 10 |
| Intuitiveness/usability of the SVS | 31 | 10 |
| Amount of display cross-checking | 28 | 13 |
| Pilots level of confidence in his/her perception of the world | 21 | 14 |
| Level of self confidence | 18 | 15 |

| RANK (2) |
| ---: |
| 65 |
| 5 |
| 15.8 |
| 59.5 |
| 49 |
| 5 |
| 70.5 |
| 65 |
| 15.8 |
| 31.5 |
| 70.5 |
| 15.8 |
| 42.5 |
| 15.8 |
| 74.5 |
| 54 |
| 70.5 |
| 77 |
| 28.5 |
| 23.5 |
| 23.5 |
| 31.5 |
| 49 |
| 23.5 |
| 15.8 |
| 49 |
| 23.5 |
| 28.5 |
| 5 |
| 8 |
| 2 |
| 23.5 |
| 3 |
| 13.5 |
| 34.5 |
| 37.5 |
| 65 |
| 10.5 |
| 28.5 |
| 54 |

| |
|---|
| 13.5 |
| 76.5 |
| 59.5 |
| 1 |
| 54 |
| 15.8 |
| 65 |
| 76.5 |
| 10.5 |
| 42.5 |
| 59.5 |
| 42.5 |
| 59.5 |
| 34.5 |
| 42.5 |
| 28.5 |
| 49 |
| 49 |
| 10.5 |
| 59.5 |
| 34.5 |
| 34.5 |
| 10.5 |
| 70.5 |
| 70.5 |
| 54 |
| 42.5 |
| 37.5 |
| 59.5 |
| 42.5 |
| 70.5 |
| 74.5 |
| 65 |
| 42.5 |
| 42.5 |
| 54 |
| 23.5 |

| RANK (2) |
|---|
| 64 |
| 64 |

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|---|
| 64 |
| 7 |
| 11 |
| 64 |
| 24.5 |
| 36.5 |
| 14 |
| 64 |
| 64 |
| 8 |
| 4 |
| 5 |
| 46 |
| 28.5 |
| 33.5 |
| 18.5 |
| 24.5 |
| 64 |
| 31 |
| 31 |
| 6 |
| 20.5 |
| 20.5 |
| 28.5 |
| 64 |
| 46 |
| 3 |
| 2 |
| 64 |
| 24.5 |
| 64 |
| 41 |
| 64 |
| 36.5 |
| 31 |
| 64 |
| 64 |
| 46 |
| 64 |
| 24.5 |
| 24.5 |
| 11 |

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|---|
| 36.5 |
| 1 |
| 16 |
| 64 |
| 64 |
| 36.5 |
| 9 |
| 64 |
| 41 |
| 46 |
| 46 |
| 64 |
| 64 |
| 64 |
| 33.5 |
| 11 |
| 64 |
| 64 |
| 64 |
| 18.5 |
| 15 |
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| 41 |
| 46 |
| 64 |
| 39 |
| 24.5 |
| 46 |
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| 64 |

| RANK (2) |
|---|
| 1 |
| 2 |
| 3 |
| 5 |
| 5 |

| |
|---|
| 5 |
| 8 |
| 10.5 |
| 10.5 |
| 10.5 |
| 10.5 |
| 13.5 |
| 13.5 |
| 15.8 |
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| RANK (2) |
|---|
| 1 |
| 2 |
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| 9 |
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| 11 |
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| 15 |
| 16 |

# Appendix F

## Tradeoff Scenarios (Varying Characteristics)

1.) Amount of time spent looking out-the-window/Difficulty of approach/landing

Relationship:

a.) When the desirability of Amount of time spent looking out-the-window ***increases***, the desirability of Difficulty of approach/landing ***increases*** or ***decreases***

b.) When the desirability of Amount of time spent looking out-the-window ***decreases***, the desirability of Difficulty of approach/landing ***increases*** or ***decreases***

c.) When the desirability of Difficulty of approach/landing ***increases***, the desirability of Amount of time spent looking out the window ***increases*** or ***decreases***

d.) When the desirability of Difficulty of approach/landing ***decreases***, the desirability of Amount of time spent looking out the window ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship (Tradeoff Possible): If the terrain surrounding the destination airport is not difficult to navigate and the weather is desirable, the PF may be able to spend more time looking out-the-window. However, if the pilot devotes too much head up time, and does not pay attention to his instruments and/or the SVS display, the approach/landing may become more difficult.

b.) Direct Relationship (Tradeoff Possible): If the PF spends less time viewing the terrain out the window, he/she will have more time to view the SVS and other instruments. This may be especially helpful in poor weather conditions, because the SVS provides an uninterrupted view of terrain. This would make the desirability of the Difficulty of the approach/landing increase. However, looking out-the-window can be used to quickly check the accuracy of the SVS. In this situation, if the PF does not spend any head up time, the desirability of the Difficulty of the approach/landing may decrease (become more difficult).

c.) Direct Relationship (Tradeoff Possible): If the approach/landing is relatively easy to navigate either because of terrain or weather conditions, then the pilot can spend more time looking out the window, and less time viewing the SVS display. However, since the SVS display may eventually replace the out-the-window view altogether, it may be desirable to have the PF looking primarily at the SVS display during the approach/landing, even if this approach/landing is relatively simple.

d.) Direct Relationship (Tradeoff Possible): This type of relationship is not easy to imagine. Presumably, if the approach/landing is very difficulty (because of terrain or weather) it would be desirable to have the pilot spend more time viewing the SVS display and less time looking out the window. However, it

**Tradeoff Scenarios (Varying Characteristics)**

may be somewhat useful for the PF to quickly check the accuracy of the SVS display of terrain by looking out the window, even in difficult approaches.

2.) Amount of time spent viewing the SVS display/Amount of time spent looking out-the-window

Relationship:

a.) When the desirability of Amount of time spent viewing the SVS display ***increases***, the desirability of Amount of time spent looking out-the-window ***decreases***
b.) When the desirability of Amount of time spent viewing the SVS display ***decreases***, the desirability of Amount of time spent looking out the window ***increases*** or ***decreases***
c.) When the desirability of Amount of time spent looking out-the-window ***increases***, the desirability of Amount of time spent viewing the SVS display ***decreases***
d.) When the desirability of Amount of time spent looking out-the-window ***decreases***, the desirability of Amount of time spent viewing the SVS display ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Tradeoff: If a pilot is spending a large amount of time viewing the SVS display, he/she is necessarily spending less time looking out-the-window. This is most likely a desirable situation, since the SVS display should be able to fully support the pilot through all phases of flight.
b.) Direct Relationship (Tradeoff Possible): If it is undesirable for the PF to spend a lot of time viewing the SVS display, then he/she can spend more time looking out-the-window. This may be a situation that is not normally desirable. However, the pilot can also spend time looking at instruments other than the SVS, and his/her time spent looking out-the-window and looking at the SVS display will decrease.
c.) Tradeoff: If the PF spends a great deal of time looking out the window, then time spent viewing the SVS display will decrease
d.) Direct Relationship (Tradeoff Possible): If the PF spends less time looking out-the-window, then it is possible to spend more time viewing the SVS display. However, the PF may also view instruments unrelated to the SVS and time spent looking out-the-window and time spent viewing the SVS display would both decrease.

3.) Amount of time spent reading instruments other than the SVS/Amount of time spent looking out-the-window

Relationship:

**Tradeoff Scenarios (Varying Characteristics)**

a.) When the desirability of Amount of time spent reading instruments other than the SVS ***increases***, the desirability of Amount of time spent looking out-the-window ***decreases***
b.) When the desirability of Amount of time spent reading instruments other than the SVS ***decreases***, the desirability of Amount of time spent looking out-the-window ***increases*** or ***decreases***
c.) When the desirability of Amount of time spent looking out-the-window ***increases***, the desirability of Amount of time spent reading instruments other than the SVS ***decreases***
d.) When the desirability of Amount of time spent looking out-the-window ***decreases***, the desirability of Amount of time spent reading instruments other than the SVS ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Tradeoff: When the PF spends more time viewing instruments unrelated to the SVS, less head up time can be spent viewing terrain.
b.) Direct Relationship (Tradeoff Possible): When it is less desirable for the PF to view instruments other than the SVS, more time can be spent looking out-the-window. However, more time can also be spent viewing the SVS display, which would decrease the amount of time spent looking out-the-window.
c.) Tradeoff: If it is desirable to have to PF spend time looking out-the-window, less head down time can be spent viewing other instruments in the cockpit.
d.) Direct Relationship (Tradeoff Possible): If it is undesirable to have the pilot looking out-the-window, more time can be spent viewing instruments other than the SVS. However, if this additional time is spent viewing the SVS display, less time will be spent viewing instruments other than the SVS.

4.) Current level of SA/Amount of time spent looking out-the-window

Relationship:

a.) When the desirability of Current level of SA ***increases***, the desirability of Amount of time spent looking out-the-window ***increases*** or ***decreases***
b.) When the desirability of Current level of SA ***decreases***, the desirability of Amount of time spent looking out-the-window ***increases*** or ***decreases***
c.) When the desirability of Amount of time spent looking-out-window ***increases***, the desirability of Current level of SA ***increases*** or ***decreases***
d.) When the desirability of Amount of time spent looking out-the-window ***decreases***, the desirability of Current level of SA ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship (Tradeoff Possible): Situation awareness may become higher because the pilot is spending time looking out-the-window (in desirable weather conditions with relatively flat terrain). However, situation awareness may become higher in other situations (such as in poor weather conditions) when the PF is spending less time looking out-the-window (and more time viewing the SVS display).

b.) Direct Relationship (Tradeoff Possible): If the pilot's current level of SA is low, he/she may spend more time looking out-the-window at the terrain environment in order to try and regain SA. However, he/she may also spend more time looking at the SVS and other instruments (and not out-the-window) in order to try and regain SA.

c.) Direct Relationship (Tradeoff Possible): If the PF is spending a great deal of time looking out-the-window, SA may be higher in good weather conditions with flat terrain. However, this may also result in decreased situation awareness if it decreases the amount of time the PF spends viewing the SVS display (in poor weather conditions with complex terrain).

d.) Direct Relationship (Tradeoff Possible): When the PF spends less time looking out-the-window, and more time looking at the SVS display, SA will most likely increase. However, there may be some situations in which decreasing time spent looking out-the-window will decrease SA. For example, when there is an inaccuracy in the terrain database, or when hardware/software is otherwise not functioning properly.

5.) Level of mental workload/Amount of time spent looking out-the-window

Relationship:

a.) When the desirability of Level of mental workload ***increases***, the desirability of Amount of time spent looking out-the-window ***increases*** or ***decreases***

b.) When the desirability of Level of mental workload ***decreases***, the desirability of Amount of time spent looking out-the-window ***increases*** or ***decreases***

c.) When the desirability of Amount of time spent looking out-the-window ***increases***, the desirability of Level of mental workload ***increases*** or ***decreases***

d.) When the desirability of Amount of time spent looking out-the-window ***decreases***, the desirability of Level of mental workload ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship (Tradeoff Possible): When the desirability of Level of mental workload decreases (mental workload is low) the PF may be able to focus more of their attention on the out-the-window scene. However, the PF may also be able to focus more on the SVS or other displays in this situation.

b.) Direct Relationship (Tradeoff Possible): When the pilots level of mental workload increases, their time spent looking out-the-window will either

**Tradeoff Scenarios (Varying Characteristics)**

increase or decrease. If mental workload is high (during landing, for example) the pilot may spend more time making sure the aircraft is at the right altitude/speed and less time looking out-the-window. However, in other phases of flight, the pilot may spend more time looking out-the-window in order to check the accuracy of the SVS display to make certain that an warning from the display is accurate.

c.) Direct Relationship (Tradeoff Possible): When the PF is spending a great deal of time looking out the window, he/she may have a low level of mental workload if weather conditions are good and the terrain is relatively easy to navigate, or a high level of mental workload because they are not focusing on important information on the SVS display (in poor weather conditions, for example) or from other instruments.

d.) Direct Relationship (Tradeoff Possible): If little time is spent looking out-the-window, the pilots level of mental workload may be low because they are instead viewing the SVS display (in poor weather conditions, for example), or high because they are viewing an inaccurate, or improperly aligned display.

6.) Amount of time spent reading instruments other than the SVS/Difficulty of approach/landing

Relationship:

a.) When the desirability of Amount of time spent reading instruments other than the SVS ***increases***, the desirability of Difficulty of approach/landing ***increases*** or ***decreases***

b.) When the desirability of Amount of time spent reading instruments other than the SVS ***decreases***, the desirability of Difficulty of approach/landing ***increases*** or ***decreases***

c.) When the desirability of Difficulty of approach/landing ***increases***, the desirability of Amount of time spent reading instruments other than the SVS ***increases*** or ***decreases***

d.) When the desirability of Difficulty of approach/landing ***decreases***, the desirability of Amount of time spent reading instruments other than the SVS ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship (Tradeoff Possible): If the PF is paying sufficient attention to instruments other than the SVS, the approach/landing may become more difficult because they are paying less attention to the SVS display or less difficult because these instruments are proving information pertinent to the current phase of flight.

b.) Direct Relationship (Tradeoff Possible): If the PF is paying little attention to instruments other than the SVS, the difficulty of approach/landing may increase because they pilot is not focusing attention on important information.

**Tradeoff Scenarios (Varying Characteristics)**

However, the difficulty of the approach/landing may decrease because the pilot can spend more time viewing the SVS display.

c.) Direct Relationship (Tradeoff Possible): When the approach/landing is relatively simple, the pilot has the option of focusing attention on the SVS or on other instruments. Where the pilot focuses his/her attention has fewer consequences in this situation.

d.) Direct Relationship: If the approach is extremely difficult, because of weather conditions, terrain, pilot fatigue, etc. it may be essential for the pilot to spend time reading instruments pertinent to that phase of flight. However, in bad weather conditions especially, it may be more important for the pilot to focus on the SVS display which provides a clear view of terrain.

7.) Amount of time spent viewing the SVS display/Difficulty of approach/landing

Relationship:

a.) When the desirability of Amount of time spent viewing the SVS display ***increases***, the desirability of Difficulty of approach/landing ***increases*** or ***decreases***

b.) When the desirability of Amount of time spent viewing the SVS display ***decreases***, the desirability of Difficulty of approach/landing ***increases*** or ***decreases***

c.) When the desirability of Difficulty of approach/landing ***increases***, the desirability of Amount of time spent viewing the SVS display ***increases*** or ***decreases***

d.) When the desirability of Difficulty of approach/landing ***decreases***, the desirability of Amount of time spent viewing the SVS display ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship (Tradeoff Possible): Ideally, when the PF is devoting attention to the SVS display, the approach/landing should be less difficult, since the SVS provides a clear view of terrain and other obstacles. However, there may be situations in which the SVS was not functioning correctly, or the terrain database or GPS was inaccurate. In this case, devoting too much time to the SVS could make the approach/landing more difficult.

b.) Direct Relationship (Tradeoff Possible): When the PF spends little time viewing the SVS display (especially in low visibility conditions) the approach/landing may be more difficult. However, spending little time viewing the SVS display may be necessary as mentioned above, when the system is not functioning properly, and the difficulty of the approach/landing would decrease because the pilot would not have to deal with inaccurate or missing information.

c.) Direct Relationship (Tradeoff Possible): In an easy approach/landing situation, the pilot may spend more or less time viewing the SVS display. This

**Tradeoff Scenarios (Varying Characteristics)**

may depend purely on pilot preference, or pilots amount of trust in the SVS, or it may be dependent on the accuracy of the components of the SVS.

d.) Direct Relationship (Tradeoff Possible): As with an easy approach, with a difficult approach the pilot may spend more or less time viewing the SVS display depending on a variety of factors such as its accuracy, pilot preference, pilot experience, etc.

8.) Current level of SA/Difficulty of approach/landing

Relationship:

a.) When the desirability of Current level of SA ***increases***, the desirability of Difficulty of approach/landing ***increases***
b.) When the desirability of Current level of SA ***decreases***, the desirability of Difficulty of approach/landing ***decreases***
c.) When the desirability of Difficulty of approach/landing ***increases***, the desirability of Current level of SA ***increases***
d.) When the desirability of Difficulty of approach/landing ***decreases***, the desirability of Current level of SA ***decreases***

Classification: Direct Relationship

Explanation of Scenarios:

a.) Direct Relationship: When the PF has a very high awareness of his surroundings and current situation, this should make the approach/landing easier to carry out regardless of the weather conditions, type of terrain, or other factors.
b.) Direct Relationship: When the PF has very low situation awareness, the approach/landing would be more difficult regardless of other factors
c.) Direct Relationship: When the terrain is easy to navigate, or the weather is desirable, for example, the pilots SA will be higher. This may be a result of low mental workload in these conditions.
d.) Direct Relationship: When the approach/landing is difficult because of any number of factors, the pilots SA will be lower. This may also be a result of high mental workload in these conditions.

9.) Level of mental workload/Difficulty of approach/landing

Relationship:

a.) When the desirability of Level of mental workload ***increases***, the desirability of Difficulty of approach/landing ***increases***
b.) When the desirability of Level of mental workload ***decreases***, the desirability of Difficulty of approach/landing ***decreases***
c.) When the desirability of Difficulty of approach/landing ***increases***, the desirability of Level of mental work load ***increases***
d.) When the desirability of Difficulty of approach/landing ***decreases***, the desirability of Level of mental workload ***decreases***

**Tradeoff Scenarios (Varying Characteristics)**

Classification: Direct Relationship

Explanation of Scenarios:

a.) Direct Relationship: When the pilot's task is relatively easy, and mental workload is low, the approach/landing will become easier to carry out regardless of other factors such as terrain, weather, or SA.
b.) Direct Relationship: When the pilot's task is more difficult, and mental workload is high, the approach/landing will become more difficult, regardless of other factors.
c.) Direct Relationship: When the conditions in which the approach/landing is attempted, or the terrain itself, is easy to carry out, then, assuming the pilot is not fatigued and instruments are functioning correctly, his/her mental workload will be relatively low.
d.) Direct Relationship: When the approach/landing is very difficult, the pilots mental workload will be higher.

10.) Intuitiveness/usability of the SVS/Difficulty of approach/landing

Relationship:

a.) When the desirability of Intuitiveness/usability of the SVS ***increases***, the desirability of Difficulty of approach/landing ***increases***
b.) When the desirability of Intuitiveness/usability of the SVS ***decreases***, the desirability of Difficulty of approach/landing ***decreases***
c.) When the desirability of Difficulty of approach/landing ***decreases***, the desirability of Intuitiveness/usability of the SVS ***decreases***
d.) When the desirability of Difficulty of approach/landing ***increases***, the desirability of Intuitiveness/usability of the SVS ***increases***

Classification: Direct Relationship

Explanation of Scenarios:

a.) Direct Relationship: If the SVS display is very intuitive to the pilot, the approach/landing will be easier to carry out, regardless of other factors. It is important to note that a display may be more or less intuitive depending on the operator's experience, or preference.
b.) Direct Relationship: If the SVS display is not user friendly, and therefore unintuitive, the approach/landing will be more difficult to carry out regardless of other factors.
c.) Direct Relationship: If the approach/landing is very difficult because of terrain, weather, pilot fatigue etc., this may require that the SVS display be extremely intuitive, since pilot mental workload may be high in this situation.

**Tradeoff Scenarios (Varying Characteristics)**

d.) Direct Relationship: If the approach/landing is very simple, the SVS can be somewhat more difficult to use because mental workload in this situation would be lower and the pilot would have more attention to allocate to the SVS.

11.) Current level of SA/Accuracy of pilots mental model of the environment

Relationship:

a.) When the desirability of Current level of SA ***increases***, the desirability of Accuracy of pilots mental model of the environment ***increases***
b.) When the desirability of Current level of SA ***decreases***, the desirability of Accuracy of pilots mental model of the environment ***decreases***
c.) When the desirability of Accuracy of pilots mental model of the environment ***increases***, the desirability of Current level of SA ***increases***
d.) When the desirability of Accuracy of pilots mental model of the environment ***decreases***, the desirability of Current level of SA ***decreases***

Classification: Direct Relationship

Explanation of Scenarios:

a.) Direct Relationship: When the PF has a high awareness of their situation and surroundings, they are also likely to have a very accurate mental model of their environment. This may be a result of experience, or a consequence of an easy approach/landing
b.) Direct Relationship: When the PF has low SA, he/she is less aware of her surroundings and therefore the environment and their mental model may therefore be inaccurate.
c.) Direct Relationship: The PF may have a great deal of experience with this specific approach/landing and therefore a very accurate mental model of the environment which would result in an increased level of SA
d.) Direct Relationship: It is also possible that the PF may have little experience with this specific approach, or may have malfunctioning instruments and therefore an inaccurate mental model of the environment which would result in a lower level of SA.

12.) Level of mental workload/ Accuracy of pilots mental model of the environment

Relationship:

a.) When the desirability of Level of mental workload ***increases***, the desirability of Accuracy of pilots mental model of the environment ***increases***
b.) When the desirability of Level of mental workload ***decreases***, the desirability of Accuracy of pilots mental model of the environment ***decreases***

**Tradeoff Scenarios (Varying Characteristics)**

c.) When the desirability of Accuracy of pilots mental model of the environment ***increases***, the desirability of Level of mental workload ***increases***

d.) When the desirability of Accuracy of pilots mental model of the environment ***decreases***, the desirability of Level of mental workload ***decreases***

Classification: Direct Relationship

Explanation of Scenarios:

a.) Direct Relationship: If the current task is relatively easy to carry out (low mental workload), then the pilot may have more time to pay attention to his surroundings through instruments or looking out the window, and would have a more accurate mental model of the environment.

b.) Direct Relationship: If the current task is very complicated and the pilots mental workload is very high, then he/she would have lower SA, which may create an inaccurate mental model of the environment.

c.) Direct Relationship: If the pilot has experience with the approach/landing and has high SA, their mental model of the environment would be very accurate. This could lead to a decrease in mental workload, regardless of other factors.

d.) Direct Relationship: If however, the pilot has little experience with the approach and has low SA, their mental model of the environment may be inaccurate, which could lead to increased mental workload even if the approach/landing is relatively easy, or the weather conditions are desirable.

13.) Amount of time spent viewing the SVS display/Amount of time spent reading instruments other than the SVS

Relationship:

a.) When the desirability of Amount of time spent viewing the SVS display ***increases***, the desirability of Amount of time spent reading instruments other than the SVS ***decreases***

b.) When the desirability of Amount of time spent viewing the SVS display ***decreases***, the desirability of Amount of time spent reading instruments other than the SVS ***increases***

c.) When the desirability of Amount of time spent reading instruments other than the SVS ***increases***, the desirability of Amount of time spent viewing the SVS ***decreases***

d.) When the desirability of Amount of time spent reading instruments other than the SVS ***decreases***, the desirability of Amount of time spent viewing the SVS ***increases***

Classification: Tradeoff

**Tradeoff Scenarios (Varying Characteristics)**

Explanation of Scenarios:

a.) Tradeoff: The relationship between these two variables is rather obvious. When the PF devotes a great deal of attention to the SVS display, his/her time spent viewing instruments other than the SVS will necessarily decrease. Since the SVS can be used exclusively for viewing terrain, especially in poor visibility conditions, this may be the ideal situation

b.) Tradeoff: When the PF spends little time viewing the SVS display, he/she will spend more time viewing instruments other than the SVS. This may result from lack of trust in the SVS, lack of experience with the SVS, some malfunction of the SVS, or a variety of other factors.

c.) Tradeoff: If the PF devotes more time to viewing instruments other than the SVS, less time will be available to devote to viewing the SVS.

d.) Tradeoff: If the PF devotes less time to viewing instruments other than the SVS, more time will be available to devote to viewing the SVS.

14.) Current level of SA/Amount of time spent reading instruments other than the SVS

Relationship:

a.) When the desirability of Current level of SA ***increases***, the desirability of Amount of time spent reading instruments other than the SVS ***increases*** or ***decreases***

b.) When the desirability of Current level of SA ***decreases***, the desirability of Amount of time spent reading instruments other than the SVS ***increases*** or ***decreases***

c.) When the desirability of Amount of time spent reading instruments other than the SVS ***increases***, the desirability of Current level of SA ***increases*** or ***decreases***

d.) When the desirability of Amount of time spent reading instruments other than the SVS ***decreases***, the desirability of Current level of SA ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship (Tradeoff Possible): A high level of SA can result from a variety of factors. The PF may need to devote a significant amount of attention to instruments other than the SVS if, for example, they contain information pertinent to the current phase of flight, the SVS is inaccurate, in order to cross-check between displays, etc. However, increased SA should also come from viewing the SVS display, especially in very low visibility conditions, in which the out-the-window view is insufficient.

b.) Direct Relationship (Tradeoff Possible): Low SA can also result from choosing to spend time viewing instruments other than the SVS, or from viewing the SVS display itself, depending on the circumstance. Ideally, when the SVS is functioning properly, it should encourage high SA. However, if the SVS display is inaccurate, if the pilot has an inaccurate machine model, or the pilot does not trust the SVS display, viewing the display may actually result in decreased SA.

c.) Direct Relationship (Tradeoff Possible): As mentioned above, devoting a significant amount of attention to instruments other than the SVS can result in an increased or decreased level of SA, depending on the circumstances.

d.) Direct Relationship (Tradeoff Possible): As mentioned above, viewing the SVS display or looking out-the-window, and not devoting attention to instruments other than the SVS can also result in an increased or decreased level of SA depending on the situation.

15.) Level of mental workload/Amount of time spent reading instruments other than the SVS

Relationship:

a.) When the desirability of Level of mental workload ***increases***, the desirability of Amount of time spent reading instruments other than the SVS ***increases*** or ***decreases***

b.) When the desirability of Level of mental workload ***decreases***, the desirability of Amount of time spent reading instruments other than the SVS ***decreases***

c.) When the desirability of Amount of time spent reading instruments other than the SVS ***increases***, the desirability of Level of mental workload ***increases*** or ***decreases***

d.) When the desirability of Amount of time spent reading instruments other than the SVS ***decreases***, the desirability of Level of mental workload ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship (Tradeoff Possible): When the PF is experiencing a low level of mental workload, presumably because the task is relatively simple (i.e. weather conditions are ideal), then he/she has the option of devoting more/less attention to instruments other than the SVS.

b.) Direct Relationship: If the desirability of the amount of mental workload decreases (high mental workload), then the PF will have less attention to devote to viewing instruments other than the SVS. In very low visibility conditions, the PF may need to devote much of his/her attention to the SVS display in order to carry out the approach/landing.

c.) Direct Relationship (Tradeoff Possible): Spending a significant amount of time viewing instruments other than the SVS can result in high or low levels of mental workload depending on a variety of factors. For example, if the PF should be looking at the SVS display and is not, mental workload may increase. However, if these other instruments are providing pertinent

**Tradeoff Scenarios (Varying Characteristics)**

information to the current phase of flight, this may result in decreased mental workload.

d.) Direct Relationship (Tradeoff Possible): As mentioned above, devoting a great deal of attention to instruments other than the SVS display can result in an increased or decreased level of mental workload depending on the situation.

16.) Current level of SA/Amount of time spent viewing the SVS display

Relationship:

a.) When the desirability of Current level of SA ***increases***, the desirability of Amount of time spent viewing the SVS display ***increases***
b.) When the desirability of Current level of SA ***decreases***, the desirability of Amount of time spent viewing the SVS display ***decreases***
c.) When the desirability of Amount of time spent viewing the SVS display ***increases***, the desirability of Current level of SA ***increases***
d.) When the desirability of Amount of time spent viewing the SVS display ***decreases***, the desirability of Current level of SA ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship: The SVS is designed to promote high situation awareness because it allows the pilot to have a clear view of terrain and other obstacles regardless of current weather conditions. Therefore, in an ideal situation, high SA should result from spending a significant amount of time viewing the SVS display.
b.) Direct Relationship: Similar to the situation mentioned above, if the PF spends little time viewing the SVS display, this will most likely result in decreased SA.
c.) Direct Relationship: As mentioned above, viewing the SVS display for a significant amount of time should result in increased SA
d.) Direct Relationship: Not devoting a great deal of attention to the SVS display should result in decreased SA.

17.) Level of mental workload/Amount of time spent viewing the SVS display

Relationship:

a.) When the desirability of Level of mental workload ***increases***, the desirability of Amount of time spent viewing the SVS display ***increases*** or ***decreases***
b.) When the desirability of Level of mental workload ***decreases***, the desirability of Amount of time spent viewing the SVS display ***increases*** or ***decreases***
c.) When the desirability of Amount of time spent viewing the SVS display ***increases***, the desirability of Level of mental workload ***increases*** or ***decreases***

**Tradeoff Scenarios (Varying Characteristics)**

d.) When the desirability of Amount of time spent viewing the SVS display ***decreases***, the desirability of Level of mental workload ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship (Tradeoff Possible): If the mental workload of the PF is low then he/she has the option of allocating more or less attention to the SVS display.
b.) Direct Relationship (Tradeoff Possible): If, however, the mental workload of the PF is very high because the weather conditions are very poor, he/she may need to spend a significant amount of time focusing on the SVS display, which is designed for use in this type of situation. However, under conditions of high mental workload, he/she may have less time to view one instrument for any extended period of time, and will most likely need to cross-check frequently between instruments.
c.) Direct Relationship (Tradeoff Possible): If the PF is spending most of their time viewing the SVS display, this can result in low or high mental workload. Mental workload may decrease if weather conditions or other factors warrant the pilot paying attention exclusively to the SVS display. However, if the SVS is inaccurate, not functioning correctly, or the pilot has an inaccurate machine model, mental workload may increase as a result.
d.) Direct Relationship (Tradeoff Possible): If the pilot spends little time viewing the SVS display, this can result in low or high levels of mental workload depending on the above-mentioned factors.

18.) Intuitiveness/usability of the SVS display/Level of mental workload

Relationship:

a.) When the desirability of Intuitiveness/usability of the SVS display ***increases***, the desirability of Level of mental workload ***increases***
b.) When the desirability of Intuitiveness/usability of the SVS display ***decreases***, the desirability of Level of mental workload ***decreases***
c.) When the desirability of Level of mental workload ***increases***, the desirability of Intuitiveness/usability of the SVS display ***decreases***
d.) When the desirability of Level of mental workload ***decreases***, the desirability of Intuitiveness/usability of the SVS display ***increases***

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship: If the SVS display is highly intuitive to the pilot, then this should result in a lower level of mental workload, regardless of other factors. This may depend on the experience of the pilot, his amount of trust in the SVS, his machine model, as well as other factors.

**Tradeoff Scenarios (Varying Characteristics)**

b.) Direct Relationship: If the SVS display is not intuitive to the pilot, then this should result in a higher level of mental workload, regardless of other factors.
c.) Tradeoff: If the PF mental workload is very low, then it is not as critical that the SVS display be extremely intuitive to him/her. Although a user-friendly interface is always desirable, it is less important under conditions of low mental workload since the pilot would presumably have more attention to devote to the display.
d.) Tradeoff: If the PF mental workload is very high, then it is extremely critical that the SVS be intuitive to that individual, since he/she will not have a great deal of time or attention to devote to the display.

19.) Difficulty of approach/landing/Amount of display cross-checking

Relationship:

a.) When the desirability of Difficulty of approach/landing ***increases***, the desirability of amount of display cross-checking ***decreases***
b.) When the desirability of Difficulty of approach/landing ***decreases***, the desirability of amount of display cross-checking ***increases*** or ***decreases***
c.) When the desirability of Amount of display cross-checking ***increases***, the desirability of Difficulty of approach/landing ***increases*** or ***decreases***
d.) When the desirability of Amount of display cross-checking *decreases*, the desirability of Difficulty of approach/landing ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Tradeoff: If the approach/landing situation is relatively easy because of terrain, weather conditions, or other factors such as experience of the pilot, the amount of time the pilot spends cross-checking will decrease. If the pilot is overly confident, he/she may not cross-check between displays enough, which could result in an error.
b.) Direct Relationship (Tradeoff Possible): If the approach/landing situation is very difficult, the PF may need to cross-check information between displays frequently in order to avoid a potential error and to increase his situation awareness, and the accuracy of his mental model of the environment. However, there may also be situations in which the approach/landing causes an increase in mental workload, and the pilot does not have the attention to devote to cross-checking between displays. In this situation it may be more desirable to have the pilot focused primarily on one instrument such as the SVS.
c.) Direct Relationship (Tradeoff Possible): If the PF is spending a significant amount of time cross-checking information, this could make the approach easier for him/her because they will have increased SA. However, if too much time is spent cross-checking information, the pilot may not be allocating enough attention to pertinent displays (such as the SVS) which

**Tradeoff Scenarios (Varying Characteristics)**

would assist in the approach/landing, and the difficulty of the approach/landing would therefore increases.

d.) Direct Relationship (Tradeoff Possible): If the PF is spending little time cross-checking information between displays, this could also make the current approach/landing more or less difficult depending on the above mentioned factors.

20.) Difficulty of approach/landing/Degree of display clutter/degree of overlay with PFD data

Relationships:

a.) When the desirability of Difficulty of approach/landing ***increases***, the desirability of Degree of display clutter/degree of overlay with PFD data ***decreases***

b.) When the desirability of Difficulty of approach/landing ***decreases***, the desirability of Degree of display clutter/degree of overlay with PFD data ***increases***

c.) When the desirability of Degree of display clutter/degree of overlay with PFD data ***increases***, the desirability of Difficulty of approach/landing ***increases*** or ***decreases***

d.) When the desirability of Degree of display clutter/degree of overlay with PFD data ***decreases***, the desirability of Difficulty of approach/landing ***increases*** or ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Tradeoff: If the approach/landing situation is relatively simple, then the desirability of the Degree of clutter will increase (low clutter level). In other words, it will be less essential for the display to be uncluttered, since mental workload will presumably be lower.

b.) Tradeoff: If the approach/landing is very difficult, for whatever reason, then it is essential that the degree of display clutter be relatively low in order to decrease mental workload for the PF and provide an intuitive, easy to read display.

c.) Direct Relationship (Tradeoff Possible): If the SVS is uncluttered, and therefore easy to read and intuitive to the PF, the approach/landing will most likely be easier for the PF to carry out since the display is more intuitive. However, the approach/landing could become more difficulty if the display has so little information that information the pilot currently needs is not displayed, and he/she has to search through the menu in order to obtain this information.

d.) Direct Relationship (Tradeoff Possible): If the SVS is very cluttered, the approach landing may be more or less difficult for the above mentioned reasons.

**Tradeoff Scenarios (Varying Characteristics)**

21.) Amount of display cross-checking/Current level of SA

Relationships:

a.) When the desirability of the Amount of display cross-checking ***increases***, the Current level of SA ***increases***.
b.) When the desirability of the Amount of display cross-checking ***decreases***, the Current level of SA ***decreases***
c.) When the desirability of the Current level of SA ***increases***, the desirability of Amount of display cross-checking ***decreases***
d.) When the desirability of the Current level of SA ***decreases***, the desirability of Amount of display cross-checking ***increases***.

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship: If the PF is spending a lot of time cross-checking information between displays, then his/her SA should increase.
b.) Direct Relationship: If the PF is spending little time cross-checking between displays, his/her SA should decrease since they are getting information primarily from one source which could be inaccurate.
c.) Tradeoff: If the PF has a high SA because he/she is very experienced with the current terrain surroundings, or has a high amount of general experience, they will not need to cross-check information between displays as frequently.
d.) Tradeoff: If the PF has very low SA, he/she may need to cross-check information between displays in order to increase their awareness of the current situation.

22.) Amount of display cross-checking/Level of mental workload

Relationships:

a.) When the desirability of Amount of display cross-checking ***increases***, the desirability of the Level of mental workload ***decreases***
b.) When the desirability of Amount of display cross-checking ***decreases***, the desirability of the Level of mental workload ***increases***
c.) When the desirability of the Level of mental workload ***increases***, the desirability of Amount of display cross-checking ***increases***
d.) When the desirability of the Level of mental workload ***decreases***, the desirability of Amount of display cross-checking ***decreases***

Classification: Unstable

Explanation of Scenarios:

a.) Tradeoff: If the PF is constantly cross-checking information between displays, his/her Level of mental workload will increase simply because they are performing more mental tasks. It is important to note

**Tradeoff Scenarios (Varying Characteristics)**

that a high degree of display cross-checking may be desirable even though mental workload may increase in these circumstances.

b.) Tradeoff: If the PF is spending little time cross-checking information between displays, his/her Level of mental workload will decrease because they are performing fewer mental tasks. Again, this may not be a desirable situation regardless of the level of mental workload.

c.) Direct Relationship: If the PF currently has a high level of mental workload, he/she will have less time to devote to cross-checking information between displays, and may need to devote their attention to one primary display (such as the SVS)

d.) Direct Relationship: If the PF currently has a low level of mental workload because of the terrain situation, weather, confidence, etc., he/she will have more attention to allocate to cross-checking information between displays.

23.) Level of mental workload/Degree of display clutter/Degree of overlay with PFD data

Relationship:

a.) When the desirability of Level of mental workload ***increases***, the desirability of Degree of display clutter/Degree of overlay with PFD data ***increases***

b.) When the desirability of Level of mental workload ***decreases***, the desirability of Degree of display clutter/Degree of overlay with PFD data ***decreases***

c.) When the desirability of Degree of display clutter/Degree of overlay with PFD data ***increases***, the desirability of Level of mental workload ***increases***

d.) When the desirability of Degree of display clutter/Degree of overlay with PFD data ***decreases***, the desirability of Level of mental workload ***decreases***

Classification: Direct Relationship

Explanation of Scenarios:

a.) Direct Relationship: When the PF is experiencing a low level of mental workload it is less important that the display maintain a low degree of clutter, because he/she presumably has more attention to allocate to the display.

b.) Direct Relationship: When the PF is experiencing a high level of mental workload is it critical that the display be easy to interpret, which may mean a low degree of display clutter. It is important however, that pertinent information still be readily available, and not buried in the menu structure in an attempt to have an uncluttered display.

**Tradeoff Scenarios (Varying Characteristics)**

c.) Direct Relationship: When display clutter is kept to a minimum, then mental workload should decrease because the display should be more intuitive and therefore easier for the pilot to interpret.

d.) Direct Relationship: When there is a high degree of display clutter, mental workload will increases because it will be more difficult for the pilot to quickly obtain needed information from the display. It is important to not however that pertinent information not be removed from the display in an effort to oversimplify the SVS because this may result in a high level of mental workload which is the opposite of what it is intended to produce.

24.) Degree of display clutter/Degree of overlay with PFD data/ Intuitiveness/usability of the SVS

Relationship:

a.) When the desirability of Degree of display clutter/Degree of overlay with PFD data ***increases***, the desirability of the Intuitiveness/usability of the SVS ***increases***

b.) When the desirability of Degree of display clutter/Degree of overlay with PFD data ***decreases***, the desirability of the Intuitiveness/usability of the SVS ***decreases***

c.) When the desirability of the Intuitiveness/usability of the SVS ***increases***, the desirability of Degree of display clutter/Degree of overlay with PFD data ***decreases***

d.) When the desirability of the Intuitiveness/usability of the SVS ***decreases***, the desirability of Degree of display clutter/Degree of overlay with PFD data ***increases***

Classification: Unstable

Explanation of Scenarios:

a.) Direct Relationship: If the SVS is uncluttered (but still displays pertinent information when needed) and is therefore easy to read and interpret it will be more intuitive and usable to the PF.

b.) Direct Relationship: If the SVS is extremely cluttered with PFD data, and it is therefore difficult to read and interpret, it will be less intuitive and usable to the PF.

c.) Tradeoff: If the SVS display is highly intuitive for reasons besides the degree of display clutter such as coloring, menu structure, etc., then it will be less critical that the display maintain a low level of clutter.

d.) Tradeoff: If the SVS display is not intuitive to the PF for reasons other than the degree of display clutter, then it will be extremely critical the SVS display maintain a low degree of clutter (while still displaying pertinent information) because this measure will help to make the display more intuitive and usable to the pilot.

# Appendix G

## Tradeoff Scenarios (Non-Varying Characteristics)

Explanation: The following characteristics were found to exist in a tradeoff relationship with other characteristics. However, these characteristics are unique in that they do not fit the definition of a characteristic used thus far in this analysis. Until this point, we have examined characteristics that vary from a desirable to and undesirable state. However, characteristics such as those listed below were also included in the analysis in order to cover all aspects of the “Machine” category. For example, the characteristic “Display Size” may have undesirable and desirable states, but the research provided in this analysis does not answer the question “Which display size is most favorable”. Because we cannot examine a tradeoff relationship containing this characteristic using the previous method, the possible tradeoff relationships containing these characteristics were looked at in a more general sense. It was simply asked, “What problems or tradeoffs, if any, can be expected when this characteristic of the system is involved?”

*Non-Varying Characteristics that were involved in tradeoff relationships include the following:*

Auditory vs. visual warning
Display size
FOV currently depicted on the SVS display
Color of symbols/text
Color of terrain
Pictorial scene information density

1.) Difficulty of approach/landing/Display size

For this analysis, it was assumed that the SVS may have three possible display sizes (757 EADI 5 x 5.25 inch, 777 PFD 6.4 x 6.4 inch, and rectangular flat-panel 8 x 10 inch). It is possible that the display size chosen could have positive and/or negative consequences, especially because the possible display sizes are of very limited space. The approach/landing phase of flight could therefore become more or less difficult for the PF depending on the SVS display size that is employed. For example, on a very small display, visual warning text may be too small for the pilot to easily notice, read, and interpret. Also, terrain detail may be lost in smaller displays, and the FOV choices able to be selected may be limited.

Despite these concerns, research conducted by Comstock, Glaab, Prinzel, and Elliot (2000) suggests that small display sizes, though not necessarily preferred by pilots, do not appear to produce performance deficits when raw horizontal and vertical guidance information is present. However, there is some evidence from pilot preference data that very small display sizes have the effect of making the aircraft appear lower to the ground than it actually is (Beringer (2000), Williams (2000), Willshire, Latorella & Glaab (2000)). This could be detrimental to the approach/landing phase of flight, and more research needs to be conducted to determine if this is in fact an issue that needs to be taken into account.

# Appendix G

**Tradeoff Scenarios (Non-Varying Characteristics)**

2.) Difficulty of approach/landing/Auditory vs. visual warning

It is presumed that the SVS will provide some type of warning when the aircraft is in danger of impacting terrain. This warning has the potential to be auditory, visual, or both. The type of warning presented has the potential to make the approach/landing phase of flight more or less difficult for the pilot depending on the type of warning used and the degree to which the pilot can easily understand this warning. Typically, auditory warnings are seen as beneficial because of their omnidirectional format (Wickens, 1998). In other words, they can be heard regardless of what the pilot is doing or where he/she is directing their attention. Obviously, a number of factors should be taken into account when deciding which type of warning the SVS should present.

*An auditory warning can be used if:*

- The display is highly cluttered, and the pilot may not see a visual warning
- The pilot is experiencing a high level of mental workload
- The pilot is not devoting a significant amount of attention to the SVS
    - This could result from a lack of trust in the SVS, an inaccurate machine model, a very high or low degree of self-confidence, a high degree of display cross-checking, etc.
- The color used for a visual warning does not have high contrast with the background used in the display

*A visual warning can be used if:*

- The display has a low degree of clutter, and the pilot can easily see a visual warning
- The pilot is experiencing a low level of mental workload
- There is a high level of noise in the cockpit
- The pilot is devoting a significant amount of attention to the SVS
- The colors of symbols and text used in the warning have an adequate degree of contrast with the background colors used in the display
- The visual warning is in a prominent place on the display
- The text of the warning is easily interpretable, and is large enough to be quickly noticed
- The text conveys to that pilot that there is a serious problem that must be taken seriously, so the pilot does not ignore the warning

3.) Difficulty of approach/landing/ FOV currently depicted on the SVS display

For the current analysis, it was assumed that FOV was selectable by the pilot from four possible choices. The FOV currently displayed during the approach/landing phase of flight has the potential to make the approach/landing more or less difficult for the pilot. Research conducted by Comstock, Glaab, Prinzel, and Elliot (2000) suggests that pilots prefer having the FOV be selectable, and also prefer to have the FOV larger at higher altitudes, and smaller as they got closer to the runway in an approach.

# Appendix G

## Tradeoff Scenarios (Non-Varying Characteristics)

This suggests that FOV may have an impact on the difficulty of the approach/landing phase of flight. Further research needs to be conducted to investigate if various FOV's affect pilot error in this phase of flight. If this is the case, then pilots should be trained on what FOV to select for various phases of flight when using the SVS display.

4.) Auditory vs. visual warning/Intuitiveness/usability of the SVS

As mentioned previously, the type of warning presented to the pilot can affect how intuitive or usable the SVS is for that individual. Various types of warnings are preferable under different circumstances. Auditory displays will be more intuitive if they warning is presented at the correct decibel level, is presented when there is a low level of noise in the cockpit, is presented in a clear tone, is presented understandably, and is presented in a way that conveys the degree of severity to the pilot. Visual warnings will be more intuitive if they are presented in large enough text that they can be easily seen by the PF, are presented in a color that contrasts adequately with the background color of the display, are in a prominent place on the display, and if they are presented in a way that conveys the severity of the present situation.

5.) Color of symbols/text/Color of terrain

This relationship merely suggests that the color of symbols and text should have adequate contrast with the colors used for the terrain displayed on the SVS display. This relationship is not meant to suggest that certain colors are more appropriate, but that the relationship between various colors used in the display should be taken into account.

6.) Color of symbols/text/Intuitiveness/usability of the SVS

Based on a large body of previous research it is obvious that the type and amount of colors used in a display can influence it intuitiveness and usability for the pilot (Christ, 1975). There is evidence that the color used for warnings, or for special symbols should be unique to that symbol or text in order to aid in easy identification. Colors for the same or similar attributes of the display should also remain consistent throughout the system, and the number of colors used should be kept in check, since a large array of colors can cause confusion, and contrast problems between elements.

7.) Color of symbols/text/Pictorial scene information density

This relationship suggests that the colors of symbols and text that will be overlaid on the terrain background should be different and have an adequate degree of contrast with this background. This is not meant to suggest that certain colors are more appropriate or intuitive, but that this relationship should be considered.

# Appendix G

## Tradeoff Scenarios (Non-Varying Characteristics)

8.) Color of terrain/Intuitiveness/usability of the SVS
Pictorial scene information density/Intuitiveness/usability of the SVS

These two potential tradeoff relationships were grouped because it was determined that the characteristics “Color of terrain” and “Pictorial scene information density” produced the same entries in the matrix, and can therefore be examined together. This is not to say that the characteristics are the same, but that they affect and are effected by other system components in similar ways.

The prototypical SVS considered for this analysis was assumed to have three possible types of terrain rendering (pictorial scene information density). The SVS may have a photo-realistic terrain display, a less detailed terrain texture display, or a wire-frame rendering of terrain. It was not the aim of this analysis to determine which type of pictorial scene information density would produce the least amount of error and would be the most intuitive and usable to the pilot. However, this relationship suggests that the type of rendering chosen has a great impact on the system and has the potential to influence the usability of the display. Further research should be conducted in order to determine which type of rendering is best for use in the SVS.

9.) Degree of display clutter/Degree of overlay with PFD data/Pictorial scene information density

This potential tradeoff relationship suggests that certain types of pictorial scene information density may allow for more or less overlaid information to be presented on the SVS. For example, a photo-realistic display may have significantly more graphics than a wire-frame rendering. This type of terrain rendering may therefore allow for less information to be overlaid on it, since it may be difficult to easily see that information because of the clutter produced. This should be taken into consideration when choosing the type of terrain rendering to be used in the SVS. A detailed, visually appealing display may not always be the best choice if many symbols, text, PFD data, etc. need to be overlaid on top of this terrain background.

10.) Display size/FOV currently depicted on the SVS display

This tradeoff relationship represents the possibility that small display sizes may limit the FOV that can be selected by the pilot. Or, if the FOV choices are not limited, there is still the possibility that the largest FOV would produce very small graphic representations on a small display. The interaction between these two characteristics needs to be considered when designing the SVS display since both were found to have a significant impact on the system.

**Tradeoff Scenarios (Non-Varying Characteristics)**

11.) Display size/Intuitiveness/usability of the SVS

Display size has the potential to influence how intuitive or usable the SVS is to the pilot. Small display sizes may have terrain renderings or symbols and text that are perceptually difficult to interpret. This can therefore influence the difficulty of the approach/landing for the pilot. Please see the tradeoff relationship “Difficulty of approach/landing/Display size” mentioned above for a more detailed explanation.

## Error Scenarios:

1. **Amount of display cross-checking/Accuracy of the pilots mental model of the environment**

   If the pilot has an inaccurate mental model of the environment surrounding the destination airport, he/she may waste time cross-checking information that appears on the SVS display in an attempt to gain a better understanding of his/her environment. If the cross-checking between displays becomes excessive, the pilot may not allocate enough time to the SVS display. This could result in inaccurate understanding of the terrain surrounding the destination airport, which could lead to errors. This error would likely be remedied with experience and training, which would effect the use of displays and facilitate an accurate mental model of the environment.

2. **Amount of display cross-checking/Amount of time spent looking out the window**

   The error in this scenario depends on the desired action. If it is desirable to have the pilot spend time looking out the window (perhaps to gain confidence in the SVS display by cross-checking its accuracy) then an error would occur if the pilot spent an excessive amount of time cross-checking between head-down displays. If there is a high level of mental workload (which is normally the case in the approach/landing phase of flight) then allocating attention to many displays to cross-check information may not be desirable. If, however, it is desirable to have the pilot cross-check between displays (most likely in conditions of low mental workload, or in order to have the pilot gain trust in the SVS display) then spending an excessive amount of time looking out the window could result in this type of error because attention is taken away from the pertinent displays.

3. **Amount of display cross-checking/Amount of time spent reading instruments other than the SVS**

   This relationship probably does not represent an error scenario because both characteristics entail the pilot spending time viewing instruments other than the SVS. In this way, the two characteristics are similar, and an error scenario is difficult to imagine.

4. **Amount of display cross-checking/Amount of time spent viewing the SVS display**

   The error in this pairing in obvious. If it is desirable to have the pilot allocate the majority of his/her attention to the SVS display, the spending time cross-checking between displays would divert the pilots attention from the SVS which could result in the pilot having inaccurate or insufficient information about the terrain surrounding the destination airport. This error will likely be remedied if the pilot has sufficient experience with, and trust in, the SVS display, and is therefore less likely to cross-check information.

**5. Amount of time spent looking out the window/Accuracy of the pilots mental model of the environment**

Because the SVS display would provide a clear picture of the outside environment regardless of weather conditions, it would be more desirable to have the pilot allocating attention to the SVS display rather than looking out-the-window for this information. Because of possible adverse weather conditions, the out-the-window view may be very limited and would therefore result in the pilot having a less accurate understanding of the environment surrounding the destination airport.

**6. Amount of time spent looking out-the-window/Amount of time spent reading instruments other than the SVS**

Like previous scenarios, the possible error represented in this pairing depends on the desired actions, which depends on the current situation. If it is desirable to have the pilot spend time looking out the window, possible in VFR conditions, then spending an excessive amount of time reading instruments could lead to errors. However, the reverse situation is more likely considering that SVS will most likely be implemented in high end businesses and commercial aircraft which fly in IFR conditions. In this case, it is more desirable to trust ones instruments and not the out-the-window view. Therefore, spending time looking out the window and not at relevant instruments in order to obtain information would result in an error.

**7. Amount of time spent looking out-the-window/Amount of time spent viewing the SVS display**

An obvious error would result in the pilot did not pay attention to the SVS display, and instead relied on out-the-window information. Because of possible adverse weather conditions, the out-the-window view may not provide clear information about the terrain environment surrounding the destination airport, while the SVS display would provide a clear view of terrain regardless of weather conditions. It is therefore more desirable for the PF to allocate attention to the SVS.

**8. Amount of time spent viewing the SVS display/Accuracy of the pilots mental model of the environment**

Because the SVS provides a accurate representation of terrain surrounding the destination airport, it should facilitate an accurate mental model of the environment. Therefore, an error would result if the pilot does not trust the SVS and therefore does not rely on it in order to gain an understanding of his/her environment.

**9. Experience and ability of the pilot/Accuracy of the pilots mental model of the environment**

For obvious reasons, if the pilot has little experience with the environment surrounding the destination airport, his/her mental model of that environment will most likely be less accurate. However, the SVS display is designed to facilitate an accurate mental model of the terrain environment, in this way, even a pilot with little experience should be able to gain a more accurate understanding of the environment.

**10. Experience and ability of the pilot/Amount of time spent looking out-the-window**

If the pilot has little experience with the SVS display, he/she is more likely to allocate attention to the out-the-window view. Because the SVS is meant to replace, or at least supplement the out-the-window view, it should provide a clearer picture of the terrain, and is a better source of information. Therefore, excessive time spent looking out-the-window could lead to errors.

**11. Experience and ability of the pilot/Amount of time spent reading instruments other than the SVS**

This scenario is very similar to number eleven (11). If the pilot has little overall experience or little experience with the SVS display, he/she is more likely to spend an excessive amount of time reading instruments other than the SVS, when the SVS is often the better source of information. This is of course dependent on the type of information that is needed, and the above error would only pertain to situations in which the relevant information is available on the SVS display.

**12. Experience and ability of the pilot/Amount of time spent viewing the SVS display**

Pilots who have little experience with the SVS, or little overall experience, are more likely to spent less time viewing the SVS display, and will therefore rely on it less for information. This is a potential error since the SVS display should provide the clearest picture of the terrain environment. This problem will likely be alleviated if the pilot gains experience with, and trust in, the SVS display.

**Note: The characteristics "Accuracy of GPS" and "Accuracy of terrain database" have been combined in the following section. This was done because the characteristics resulted in the same entries in the matrix, and therefore, for our purposes, they have the same influence and sensitivity in the system, and can be considered together.*

**13. Accuracy of the GPS/Terrain database/Accuracy of the pilots mental model of the environment**

The error in this pairing is obvious. If the GPS/Terrain database is inaccurate, the pilot's metal model of the environment will be somewhat inaccurate. Inaccuracy of the GPS/Terrain database will also result in the pilot putting less trust in the SVS and therefore relying on it less.

**14. Accuracy of the GPS/Terrain database/Amount of time spent looking out-the-window**

If the GPS/Terrain database provides an inaccurate rendering of the terrain environment, and the pilot is aware of this because the images of the SVS and the out-the-window view are not aligned, then he/she will ignore the SVS display and will rely on the out-the-window view for terrain information. This is an error because the SVS is meant to enhance the pilots understanding of the terrain environment. The proper functioning of this system is therefore essential.

**15. Accuracy of the GPS/Terrain database/Amount of time spent reading instruments other than the SVS**

This error scenario is similar to number fifteen (15). If the GPS/Terrain database is inaccurate, and the pilot is aware of this malfunction, then he/she will spend more time viewing instruments other than the SVS.

**16. Accuracy of the GPS/Terrain database/Amount of time spent viewing the SVS display**

Again, if the GPS/Terrain database is inaccurate, and the pilot is aware of this, he/she will not allocate attention to the SVS, and will instead obtain needed information from other pertinent displays.

**17. Glare on the SVS/Accuracy of the pilots mental model of the environment**

If the glare on the SVS display is intense enough that the pilot can not accurately read information on the display, then the PF will have a less accurate mental model of the environment. In order to correct this error, the SVS display should be sunlight readable and tested in various positions on the cockpit.

**18. Glare on the SVS/Amount of time spent looking out-the-window**

This pairing represents an obvious error. If there is a intense glare on the SVS and the pilot is having a difficult time getting information from the display, then he/she will allocate his/her attention elsewhere.

**19. Glare on the SVS/Amount of time spent reading instruments other than the SVS**

This pairing is essentially the same as number nineteen (19). If the SVS display is unreadable, the PF will allocate attention to instruments other than the SVS.

**20. Glare on the SVS/Amount of time spent viewing the SVS display**

Again, if the SVS display is unreadable, the pilot will spend less time viewing it, and will obtain needed information from other instruments.

**21. Limitations of the machines processor/Accuracy of the pilots mental model of the environment**

If the machine's update rate or processor is slow, the display of current terrain information will be delayed, and there will be a misalignment between the SVS display and the out-the-window view. This will result in the PF having a less accurate mental model of the terrain environment, especially in IFR like conditions. It is therefore essential that the two images are aligned as closely as possible. This situation could be further improved by using the proposed FLIR sensor in order to check the accuracy of the GPS and terrain databases.

**22. Limitations of the machines processor/Amount of time spent looking out-the-window**

If the display of current terrain information is delayed because of processor limitations, and the images from the SVS display and out-the-widow do not align, then the PF will spend more time looking out-the-window and less time viewing the SVS display. This is an error because the purpose of the SVS display is to provide a clearer picture of the terrain environment, and it is therefore undesirable to have the pilot gain this information from the out-the-window view instead. This is especially true if weather conditions are making it difficult to clearly view terrain out-the-window.

**23. Limitations of the machines processor/Amount of time spent reading instruments other than the SVS.**

Similar to the scenario in number twenty-three (23), if the images displayed on the SVS are delayed, the SVS will be less usable, and the PF will most likely allocate less attention to the SVS display.

**24. Limitations of the machines processor/Amount of time spent viewing the SVS display**

The error here is quite obvious. If the images displayed on the SVS are delayed because of processor limitations, the information on the SVS will be less accurate and the PF is more likely to rely less on the SVS display, and therefore spend less time viewing it.

**25. Pictorial scene information density**

*Note: The characteristic “Pictorial scene information density” is paired with the characteristics “Accuracy of the pilots mental model of the environment”, “Amount of time spent looking out-the-window”, “Amount of time spent reading instruments other than the SVS”, and “Amount of time spent viewing the SVS display” in the error scenario matrix. Because this analysis did not attempt to determine which type of pictorial scene information density (photo-realistic, less detailed terrain texture, or a wire-frame) was most desirable, it is difficult to determine what the affect of each of these types would be on other characteristics. It should simply be taken into account that the type of rendering chosen has the potential to effect how accuracy of the pilot’s mental model of the environment is, and how much attention the pilot devotes to the SVS display. The specifics of these relationships will be able to be determined with current research, which is attempting to determine the advantages and disadvantages of the various depictions.

## Appendix H

SVS Error Matrix

| **Drivers** / **Receivers** | Accuracy of pilots mental model of the environment | Amount of time spent looking out-the-window | Amount of time spent reading instruments other than SVS | Amount of time spent viewing the SVS display |
|---|---|---|---|---|
| Amount of display cross-checking | 1 | 1 | 1 | 1 |
| Amount of time spent looking out-the-window | 1 | | 1 | 1 |
| Amount of time spent viewing the SVS display | 1 | 1 | 1 | |
| Experience and ability of the pilot | 1 | 1 | 1 | 1 |
| Accuracy of GPS | 1 | 1 | 1 | 1 |
| Accuracy of terrain database | 1 | 1 | 1 | 1 |
| Glare on SVS | 1 | 1 | 1 | 1 |
| Limitations of the machines processor | 1 | 1 | 1 | 1 |
| Pictorial scene information density | 1 | 1 | 1 | 1 |